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Alternative Approaches and Special Applications

Edited by Gastón Ares and Paula Varela



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Woodhead Publishing Series in Food Science,
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Methods in Consumer Research, Volume 2

Alternative Approaches and Special
Applications

Edited by

Gastón Ares

Paula Varela



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An imprint of Elsevier

Woodhead Publishing is an imprint of Elsevier
The Officers' Mess Business Centre, Royston Road, Duxford, CB22 4QH, United Kingdom
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States
The Boulevard, Langford Lane, Kidlington, OX5 1GB, United Kingdom

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Library of Congress Cataloging-in-Publication Data

A catalog record for this book is available from the Library of Congress

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-0-08-101743-2 (print)

ISBN: 978-0-08-101744-9 (online)

For information on all Woodhead Publishing publications visit our website at
<https://www.elsevier.com/books-and-journals>



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Publisher: Andre G. Wolff

Acquisition Editor: Megan R. Ball

Editorial Project Manager: Karen R. Miller

Production Project Manager: Debasish Ghosh

Designer: Mark Rogers

Typeset by TNQ Books and Journals

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Preface

Understanding consumers' attitudes, perceptions, and behaviors is of vital importance for food choice research and new product development, but also for policy making, to support various current societal challenges. The consumer science field emerged in the first half of the 20th century, mainly as a support to product development and to identify the main drivers of preferences. Since the late 20th century, the complexity of consumer behavior has been increasingly acknowledged and researchers have become interested in studying other aspects of product consumption that also play a relevant role in consumers' decision-making processes. To achieve a more holistic view of consumer behavior, several methodologies have been added to the toolbox of consumer researchers, to address aspects of consumer behavior that have previously not been much explored. In this context, this book aims to provide a comprehensive overview of the latest methodological advances in consumer research, including approaches to classical methods, adaptation of methods from other areas of knowledge, and new tools that have been brought into use by consumer researchers with new technologies.

The book is structured in two volumes and various sections, each related to a different aspect of consumer perception and behavior. The first volume is focused on new approaches to classical methods in consumer research. It includes four main sections dedicated to qualitative techniques (focus groups, ethnography, and the use of social media to study consumer perception), methodologies to measure affective responses to products (liking, conceptual associations, and emotional responses), consumer segmentation (statistical methods and new segmentation strategies), and methodological approaches to studying the influence of extrinsic product characteristics on consumer perception. The second volume provides a comprehensive overview of novel and emerging methodologies and their innovative applications. It is also composed of four sections, related to in-context consumer research (including the application of evoked contexts, immersive techniques and virtual reality, and methodologies for evaluating meals and food pairings), food and health-related issues in consumer research (food intake, satiety and satiation, and well-being), implicit and physiological measurements (implicit associations, eye tracking, face reading, EEG and fMRI), and consumer research on specific populations (children, elderly, and low-income populations) and nonfood products.

The book intends to address all the topics from an applied perspective, providing the relevant theories concisely for purposes of understanding, but focusing on their application by using examples and critically discussing the potentialities and drawbacks of each methodology. Each chapter includes a detailed example of application, to enable readers to understand how to design, implement, and analyze data from studies involving the methodological approaches discussed. Although emphasis is made on consumers' perception of food products, specific aspects of consumer research with nonfood products are also presented.

The aim of this book is to provide the reader with a complete, actual, and critical view of recent developments in consumer research, as well as updates to classical methods and upcoming trends in the field. It is expected to become a reference for people working to understand consumer perception in various fields, such as sensory and consumer science, psychology, marketing, and nutrition. We hope this book encourages more interdisciplinary scientific research to understand consumer perception of products. It is also our sincere wish to increase the impact of consumer research by contributing to solving some of the societal and health problems we currently face worldwide. We hope that readers will enjoy the book and find it as inspiring as we do.

Gastón Ares and Paula Varela

Part I

Doing Consumer Research

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Chapter 1

Contextual Influences on
Consumer Responses to Food
Products

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1. INTRODUCTION

1.1 Terminology

This chapter deals with the subject of “context,” which covers a very broad range of phenomena. We use context to refer to “the situation in which something happens: the group of conditions that exist where and when something happens” (Merriam-Webster’s Dictionary, 2016, online [Merriam-Webster.com](https://www.merriam-webster.com)). When we apply this definition to sensory and consumer research, we open up all of the situations in which sensory and consumer research come to bear on products and situations. This includes relatively simple situations, such as whether a sweet solution is made with distilled water or added to fruit juice, or more complex laboratory studies in which food items or serving vessels are varied to examine their influence on foods, all the way to serving multicomponent meals in a home setting, school, or restaurant.

Context is not the only word used in relationship to “the situation in which something happens.” The words *environment* and *setting* are also used and usually refer to the physical location—a laboratory, restaurant, dining room, home kitchen, etc. The word *situation* is often used more broadly, much like the word *context*. The variables involved with both “context” and “situation” are called contextual or situational variables. These variables can be product variables (for example, the foods served with other foods), social variables (for example, the people present), and physical environmental variables (for example, lighting, sound, etc.). Some models of context might also include economic variables, such as price.

Two other words are needed to set the scene for this exploration of context, *natural* and *real*. Some researchers want to describe certain contexts as natural or real and other contexts as not natural or not real. *Natural* means that something exists in nature. People do not naturally eat their lunch in a laboratory, so

that is not a natural setting. The word *real* refers to something that exists, rather than something imagined or artificial.

Consider again the laboratory meal—it is not a natural meal, but it might be considered a real meal, because it does exist and is not imagined. When we use written descriptions of meals, they are not natural and not real. The contextual literature is filled with authors trying to attach the words *natural* and/or *real* to particular methods and particular situations.

Context and the related words *situation*, *environment*, and *setting* are often used with specific adjectives to further identify a specific area of interest. These adjectives include economic, physical, social, economic, cultural, and others. Studying the economic context of a product might include measuring the effect of price on consumers' willingness to purchase it or it might involve the segmentation of consumers into high and low income to assess differential effects on perceived quality of foods. Physical context, as noted before, might be synonymous with the term environment or setting. Variables in the physical context could include lighting, noise, and furnishings. Social context is of interest to a broad range of research disciplines including psychology, anthropology, sociology, and marketing. Variables in the social context might include product usage, dining alone or in groups, or the influence of different types of individuals on product assessment. Cultural context is a large area of study, and cross-cultural sensory and consumer research is becoming more important in this era of rapid globalization. One part, but not the only part, of cross-cultural context involves the challenges of repeating research in different parts of the world with comparable instructions and response formats, given the differences in languages.

1.2 The History of Studying Context

As sensory psychophysics and sensory testing began to develop, Rosemary Pangborn was one of the first to examine sensory stimuli in foods and not just in simple taste solutions. She used taste stimuli in a food context, such as sugar in lemonade (Pangborn, 1980), an approach subsequently used by many others, e.g., DuBose, Cardello, and Maller (1980) at Natick Laboratories.

The behavioral scientists at Natick Laboratories began to investigate contextual effects on food acceptability and food consumption in the 1980s. Meiselman, Hirsch, and Popper (1988) presented a model of food choice and consumption that included situational factors at the Food Acceptability conference at the University of Reading, UK, in 1987. Their data came from studies of US soldiers and students reported in 1985 and 1987 (these data are presented in Section 7 under non-laboratory approaches). They tried to explicitly move beyond the simple sensory model when examining factors contributing to food consumption. This approach was more recently emphasized by Schifferstein (2010): “this (psychophysical laboratory) approach has its limitations for understanding food perception, because food products may be consumed in many different settings (e.g., at home, in a restaurant, in an aircraft), while consumers are influenced by the characteristics of

the environment (e.g., lighting conditions, cutlery, atmosphere) and information they have obtained previously (e.g., from advertising or consumer education)."

During the period 1990–2010, a number of researchers studied contextual effects. This period began with calls to study eating in more natural contexts rather than in controlled laboratory settings (Meiselman, 1992; Pliner & Rozin, 2000; Rozin & Tuorila, 1993). Rozin and Tuorila (1993) spoke at the first Pangborn Sensory Science Symposium, beginning by offering a definition of context: "...context will be taken to mean that set of events and experiences that are not part of the reference event but have some relationship to it" (Rozin & Tuorila, 1993, p. 11–12).

Rozin and Tuorila (1993) also dichotomized contextual influences into those that are "simultaneous" and those that are "temporal" in nature. Simultaneous influences were defined as those in which contextual and target stimuli occur at the same time, and temporal influences were defined as those in which the contextual stimulus appears before or after the target stimulus. These investigators further made the distinction between "intrinsic" and "extrinsic" contextual effects, where by intrinsic effects were defined as those that occur among variables that comprise the stimulus itself, e.g., ingredients within the food/beverage matrix, and extrinsic effects were those that resulted from influences that are entirely external to the target stimulus. Finally, Rozin and Tuorila (1993) distinguished among contextual events that occur within different "units of analysis," i.e., at the level of the bite or sip, the food or dish, the meal, etc.

Another important issue raised by Rozin and Tuorila in their review was that the important context for most eating is the meal. They noted that the sip or bite might be more appropriate for sensory testing, but that the meal is the appropriate unit for contextual research on eating, especially in natural contexts. The meal was also the focus of a 2001 meeting of the Oxford Symposium on Food and Cookery; the papers were edited by Walker (2002) and published. Meiselman et al. have examined the importance of meals in two edited books (Meiselman, 2000, 2009). However, individual food products continue to be the main focus in most sensory and consumer research on eating.

1.3 Food Choice Models That Include Context

Most models of food acceptance or food choice emphasize the role of sensory inputs (Cardello, 1996; Tuorila, 2007). However, Cardello (1994) presented a broader range of variables in his model of food choice behaviors, including cultural influences affecting the determination of acceptability and situational factors influencing product choice or purchase behavior, although the physical environment does not appear in the model. Cardello and Wise (2008) also included context as a factor in their review of the chemical senses, and Prescott (2012) included context, both physical and social, in his contemporary view of the senses, especially taste.

Sobal et al. introduced a conceptual model of the food choice process, emphasizing the social science factors more than the sensory and biological factors (Furst,

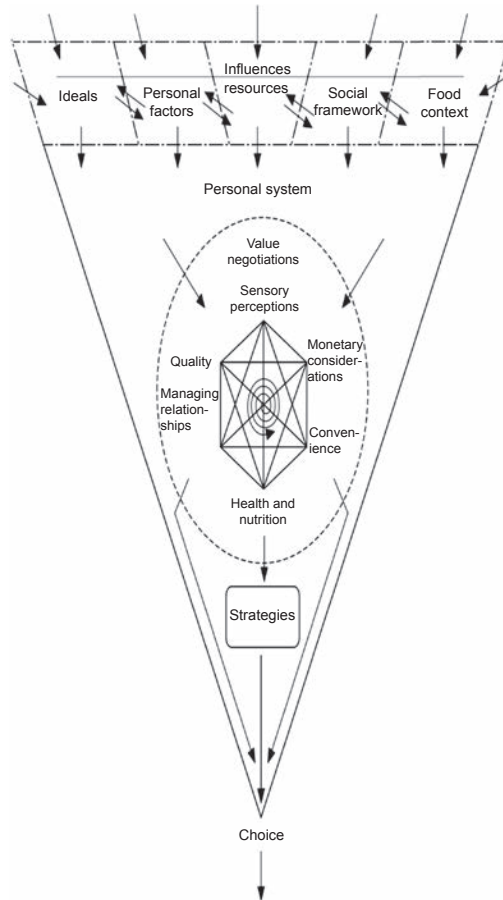


FIGURE 1.1 A conceptual model of the components in the food choice model. (From Furst, T., Connors, M., Bisogni, C. A., Sobal, J., & Falk, L. W. (1996). *Food choice: a conceptual model of the process*. *Appetite*, 26(3), 247–266.)

Connors, Bisogni, Sobal, & Falk, 1996; see also Sobal, Bisogni, Devine, & Jastron, 2006). The model (Fig. 1.1) includes both “food context” and “social factors” as influences, as well as convenience and money. Versions of the model were also developed for subgroups, including the elderly (Falk, Bisogni, & Sobal, 1996).

Some recent reviews and models of factors contributing to food choice have included many contextual factors. The 2005 report from the European Food Information Council (EUFIC, 2005) laid out the major determinants of food choice as hunger, but also:

Biological determinants, such as hunger, appetite, and taste

Economic determinants, such as cost, income, and availability

Physical determinants, such as access, education, skills (e.g., cooking), and time

Social determinants, such as culture, family, peers, and meal patterns

Psychological determinants, such as mood, stress, and guilt, as well as attitudes, beliefs, and knowledge about food

Clearly, these determinants involve a number of variables that are commonly studied as contextual factors, e.g., physical context, social and cultural context, economic context, eating alone versus with others, eating inside versus outside the home, and the interaction of the food within a meal or snack context.

Mojet (cited in [Koster, 2009](#), [Fig. 1.2](#)) presented a very complete model of the factors involved in eating and drinking. Note the switch from the product focus (food, drink) to the behaviors of eating or drinking in [Fig. 1.2](#). The factors include psychological, biological, product, sociocultural, and situational factors. The situational factors include the temporal, physical, and social environment.

Meiselman covered context in his review of factors affecting food choice, food acceptance, and food consumption ([Meiselman, 2006](#)), and later reviewed physical and social context ([Meiselman, 2008](#)). [Fig. 1.3](#) is taken from [Meiselman \(2008\)](#).

Recently, [Haugaard, Stancu, Brockhoff, Thorsdottir, and Lahteenmaki \(2016\)](#) modeled the factors relating to meal satisfaction in a workplace canteen environment, including the factor of “perceived ambience.” Interestingly, while social context and buffet assortment (food context) are included, physical context is not.

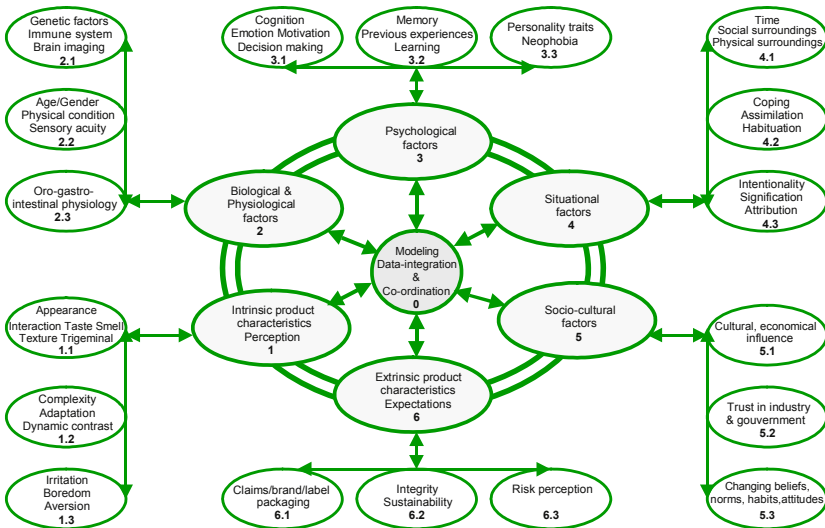


FIGURE 1.2 Essential factors that influence eating and drinking behavior and food choice. (From [Koster, E. P. \(2009\). Diversity in the determinants of food choice: a psychological perspective. Food Quality and Preference, 20, 70–82; after Mojet.](#))

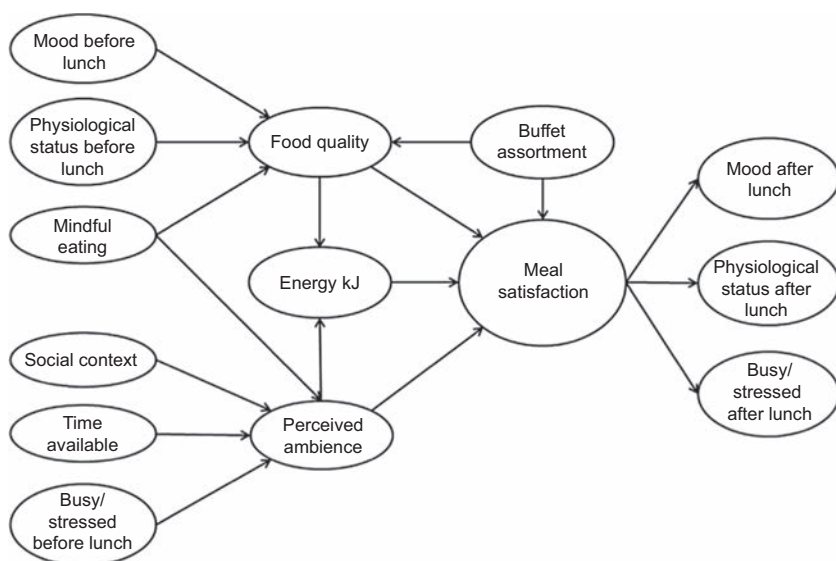


FIGURE 1.3 Conceptual model of direct and indirect factors involved in meal satisfaction. (From Meiselman, H. L. (2008). *Experiencing food products within a physical and social context*. In H. N. J. Schifferstein & P. Hekkert (Eds.), *Product Experience*. Oxford: Elsevier.)

1.4 Lab-Based Versus Natural Approaches to Context: Advantages and Limitations

Before we look more deeply into the specific elements of contextual research, it is worth reviewing the two very different types of research into context that currently exist: laboratory tests and natural or real-world tests. The tradition within sensory research has been to conduct contextual research in the laboratory. This is because many of the people who conduct sensory and consumer research were trained in traditional laboratory testing methods. This has the advantage that sensory practitioners know how to control a testing situation when that is needed. However, sensory and consumer scientists are sometimes called upon to conduct testing outside of the laboratory, e.g., in the home, in a restaurant, or in an institutional setting, such as a school or hospital. In these situations, sensory practitioners might be uncomfortable working outside of the laboratory. In addition, much research is now being conducted over the Internet and on smartphones.

The advantage of lab-based studies is that they control for extraneous and confounding variables that occur in most real-life situations. This ability to control sources of variability, noise, and distraction to the consumer enables greater sensitivity to small, but robust effects. Uncovering such subtle effects has both benefits and potential drawbacks. The benefit is that, by uncovering these small but potentially important effects, one obtains a better understanding

of the various contextual mechanisms that may operate in real-life situations, but can be obscured by the noise and extraneous variables that operate in these environments. The drawback is that such effects, while “real” and apparent in the laboratory, may have little or no relevance in real-life situations.

There are two other practical advantages to laboratory research on context. One advantage is that it informs other researchers conducting food-based studies in the laboratory about potentially uncontrolled variables that can influence their data. Thus, contextual research on the role of the color, size, or shape of serving vessels in the sensory perception or acceptance or consumption of foods serves to inform all food/sensory researchers of these potentially confounding variables and of the degree to which their results, when based on one unique set of testing variables, may be limited in how well they can be generalized to other situations. Second, certain other effects, such as the interactive effects of different components of a meal on their mutual perception or acceptance, can provide insights about potentially important variables that need further study in naturalistic settings to confirm their real-life importance to consumer behavior.

The main disadvantage of laboratory methods for studying context is that they lack external validity. This fact has been supported by a number of studies comparing lab-based (CLT) tests to “real-life” tests in restaurants or other natural settings (see [King, Meiselman, Hottenstein, Work, & Cronk, 2007](#); [King, Weber, Meiselman, & Lv, 2004](#); [Meiselman, 2000](#) for data and discussions). In laboratory settings, the physical location is more neutral and often sterile for the context of food and eating, and it is often difficult to isolate and measure the effect of the laboratory environment itself. Of course, in natural settings the physical location is often not neutral and could evoke positive expectations (e.g., a well-known restaurant) or negative expectations (e.g., a school cafeteria or airline), and in order to test whether any laboratory study predicts the real world, one must really run both the laboratory and the non-laboratory tests.

In nonlaboratory settings, usually one cannot control the situation. Natural settings are by their very nature uncontrolled. In the laboratory, one can better control the standardization of food samples; in nonlaboratory settings, one usually has to accept the food as delivered. One can try to standardize food quality, but there is less control and sometimes no control. [de Castro \(2000\)](#) has discussed the promises and the challenges of nonlaboratory testing: “In the real world most behaviors are affected by multiple causal factors ... A variable that may significantly alter behavior in the laboratory may have little or no effect in the real world due to a compensatory reaction or a modulating influence of another variable.” And he notes one of the challenges: “Of course, the lack of control in natural-environment studies presents a separate set of challenges.”

Last, in nonlaboratory settings, usually one has to deal with the customers who show up. This contrasts with research in the laboratory, where one can

TABLE 1.1 Common Conditions Occurring in Natural and Laboratory Eating Situations

Natural	Laboratory
Where people normally eat	Not a regular eating environment
Real customers	Recruited customers
Social setting	Isolation, not social
Appropriate time	Inappropriate time
Appropriate duration	Inappropriate duration
Real portion	Usually small portion
Choice of foods	No choice
Normal food combinations	No normal food combinations
Meals	Either no meals, or artificial meals
Normal desire to eat	No normal desire to eat
Normal amount usually consumed	Not a normal consumption amount
Foods eaten in normal sequence	Foods not eaten in normal sequence

choose consumers to match one's target segment. Of course, these consumers will not be regular customers of that location. In nonlaboratory settings, consumers can be regular customers of that location, and most commercial testing is done on regular product users. [Table 1.1](#) lists other differences between laboratory testing and natural testing.

A broader view of nonlaboratory/field testing has been presented by [Payne and Wansink \(2010\)](#), who present a realism (external validity)–control (internal validity) model of research. They note that new product failures often can be attributed to not studying consumers in the contexts in which they actually interact with the products. They discuss observational studies (the most realistic environment), marketplace studies (controlled designs possible), and hybrid studies in which laboratory controls are exerted in a natural location (the least realistic environment). The authors discuss Internet testing, noting that it can be conducted in the natural environment in which consumers interact with products.

While we are discussing advantages and limitations of laboratory and natural testing, we should discuss why some sensory and consumer research does not even consider the context in which the food is eaten. The most basic reason is that much/most of the research on food is exactly that, research on the chemical and physical properties of food ingredients and food products. Much

of this research occurs within the fields of food science and food technology, and this has been and remains the dominant technical approach to foods. This is also the main interest of food companies, who develop new food products and modify existing products by adding new flavors or substituting ingredients. The other main focus is on the consumer who purchases and consumes food products. Consumers are the main focus of social scientists and marketing specialists—they focus on the person, and not as much on the food itself. This raises the question of what industry or academic groups are specifically focused on the context in which the consumer and the food meet? The answer is that no group is focused on this interaction of person, product, and place, or consumer, food, and context. And, so, in the early years of research on products and consumers, context was not included as a major topic. In the late 20th century, some researchers began to include context as one of the factors in predicting outcomes, but it still has not achieved the same status as product research or consumer research (Meiselman, 2013).

One argument against the study of context that is used by those who are not comfortable with contextual research, especially research in natural eating situations, is the assumption that it will be expensive. This reflects the fact that much research conducted by the food industry is done on a contractual basis, and they assume that contextual research would be done the same way. But many natural food environments, like restaurants, are willing to share their facilities with researchers at little or no cost. And most academic researchers have university cafeterias in their own environments, often available at no cost. One must keep in mind that access to these restaurants and cafeterias usually involves accepting the situation as one finds it—as noted previously, natural environments are uncontrolled.

1.5 Objectives of the Chapter

Given the large number of research studies that have been conducted on context, especially within the past 10 years, it is impossible to cover every study. In this chapter, we hope to cover the main areas of contextual research and some of the most important studies, both those conducted in laboratory settings and those conducted in natural environments. In this way, we hope to give the reader a sense of both the wide nature and the importance of contextual research within the fields of sensory and consumer research. We will start our coverage with lab-based studies and then move to research in more natural settings.

2. LABORATORY-BASED RESEARCH ON CONTEXT

For purposes of our discussion of lab-based contextual effects, we define contextual effects as “stimuli, events, or experiences that are not part of the target stimulus, event, or experience, but that affect perceptions, affect, or cognitions of it.” We further categorize these effects in terms of the different environments

in which the causal elements of context operate, i.e., those that operate within “the temporal environment,” “the information environment,” “the physical environment,” and “the meal environment.”

2.1 Methods and Approaches Used in Lab-Based Contextual Research

As noted in the Introduction, early research on context evolved out of basic sensory science studies focused on the interactions of the sensory and/or ingredient variables that were intrinsic to the product, e.g., how does the taste of sugar change when it is either dissolved in water or dissolved in a solution of citric acid? Such studies, often conducted by psychophysicists or food scientists, are numerous, but beyond the scope of the present chapter, because our focus here is on *extrinsic* contextual effects. However, excellent reviews of the intrinsic contextual/sensory interactions among taste, smell, color, and texture of foods and beverages, which occur within individual bites or sips of food, can be found in papers by [Keast and Breslin \(2003\)](#), [Delwiche \(2004\)](#), [Small and Prescott \(2005\)](#), [Verhagen and Engelen \(2006\)](#), [Auvray and Spence \(2008\)](#), [Shankar, Levitan, and Spence \(2010\)](#), [Spence \(2011a\)](#), and [Zellner \(2013\)](#). Our main focus here will be on contextual research involving the effects of variables that are extrinsic to the individual bite or sip. Such studies include those that address the temporal effects of one sample presentation on another, the role of information (e.g., product and brand names, ingredient or health labels, price, information about the source, storage, and processing of the food) on product experience, and the roles of such other extrinsic variables as packaging, plates and serving vessels, utensils, lighting, music, décor, and accompanying food items on the acceptance, choice, and consumption of the target product.

2.2 Situational Appropriateness: An Early Lab-Based Approach to Context

Because early lab-based research on contextual effects was primarily focused on interactions among ingredients within the food, no significant attempts were made by lab-based researchers to study foods within the broader situational context. Starting in the early 1970s, attempts began to be made to study more complex contextual effects within the confines of the laboratory.

One of the simplest methods first adopted by lab-based researchers to assess contextual effects on food was introduced by Schutz et al. (see [Schutz, Rucker, & Russell, 1975](#)). This methodology was aimed at assessing the *situational appropriateness* of foods and other consumer products using a simple survey format by which “food names are rated for degree of appropriateness for a wide variety of consumption situations and uses, including time, person, location, health factors, sensory characteristics and economic considerations” ([Schutz, 1988](#)).

With the aid of a printed “food $\times$ use matrix,” a food could be rated from “never” to “always” for its appropriateness for use, e.g., “as a breakfast food,” “when one wants a snack,” “on a hot day,” “to serve at a party,” or for any one of an infinite number of physical and environmental consumption situations. Following its introduction, situational appropriateness was used in a variety of studies to assess the degree to which any product “fit” different use or consumption situations (e.g., Cardello et al., 2016; Cardello & Schutz, 1996; Cardello, Schutz, Snow, & Leshner, 2000; Elzerman, Hoek, van Boekel, & Luning, 2011, 2015; Jack, Piggott, & Paterson, 1994; Jaeger, 2000; Jaeger & MacFie, 2001; Lhteemki & Tuorila, 1995, 1997; Raats & Shepherd, 1991; Schutz, Cardello, & Winterhalter, 2005), and recently, Kster and Mojet (2015) have emphasized the important role of the situational context and the appropriateness of the product for that context in their analysis of emotional responses to foods.

As the application of food $\times$ use matrices to study contextual effects began to grow, lab-based investigators soon modified the basic procedure, in terms of both the dependent variables that were measured and the way in which the contexts were presented. For example, Cardello, Bell, and Kramer (1996) modified the item $\times$ use procedure to obtain ratings of the expected quality and liking of different foods in different “real-life” consumption contexts, e.g., “in a fast food restaurant,” “in a school cafeteria,” “at home,” etc. Similarly, the manner in which both the items and their contextual use situations were presented changed from short, one or two word phrases to longer phrases and sentences, to better capture the targeted context in the consumer’s mind. Pursuit of this goal led logically to the use of graphic representations of the targeted concepts (see also Section 2.3). For example, Fig. 1.4 shows the contextual situation presented to consumers in a study of the appropriateness of different beers in different use contexts, shown in the form of photographs of specific eating situations accompanied by a descriptive caption (Giacalone et al., 2015). In a further extension of this graphic approach, Elzerman et al. (2015) had subjects rate the appropriateness of different meat substitute ingredients using both photographs of the test items (photographs in first column of Fig. 1.5) and their different use situations, i.e., in prepared dishes (photographs across the top of Fig. 1.5). As can be seen in the table, large differences in the appropriateness of the various ingredient forms for use in the different dishes were found using this approach.

2.3 Methodological Advances in Lab-Based Research on Context: Evoked and Virtual Contexts

The previous approaches of using graphic stimuli to establish food product contexts in the laboratory were part of a gradual movement to attempt to create a more ecologically valid paradigm for studying context in the laboratory. The approach of using a written scenario to describe the contextual situation derives from the marketing literature (Bitner, 1990; Surprenant & Solomon, 1987) and



As an alternative to wine for dinner



Watching a rugby game on TV at home

FIGURE 1.4 Sample images used for visual elicitation of food contexts used by [Giacalone et al., 2015](#).

was first formally introduced into the food choice and acceptance literature by [Jaeger and Meiselman \(2004\)](#). These investigators, among others, soon began to develop more detailed approaches and methods for utilizing verbal descriptions of contextual situations, e.g., for use in discrete choice ([Jaeger & Rose, 2008](#)) and even self-report ([Loose & Jaeger, 2012](#)) methods. Furthermore, these and other investigators developed and championed the use of multimodal approaches to create more realistic contextual situations in the laboratory—methods that now have come to be called “evoked contexts” ([de Andrade et al., 2016](#); [Hein, Hamid, Jaeger, & Delahunty, 2010, 2012](#); [Hersleth, Monteleone, Segtnan, & Næs, 2015](#); [Jaeger & Rose, 2008](#); [Lusk, Hamid, Delahunty, & Jaeger, 2015](#); [Piqueras-Fiszman & Jaeger, 2014a, 2014b, 2014c, 2015a, 2015b](#)).

Although evoked contexts have been shown to highly differentiate consumer responses to the same food under different use contexts, such contexts

Meat substitute ingredient		Dish					
		Spaghetti	Rice	Wrap	Pizza	Pasta salad	Soup
							
	Mince	81.6 ^a	50.2 ^c	75.9 ^a	65.8 ^a	48.6 ^a	44.4 ^{ab}
	Strips	58.6 ^b	61.8 ^b	58.0 ^b	43.6 ^c	50.4 ^a	43.6 ^a
	Pieces	57.7 ^b	66.8 ^a	53.5 ^c	48.1 ^b	50.3 ^a	43.8 ^a
	Slices	38.9 ^d	30.6 ^d	29.5 ^e	60.7 ^a	42.6 ^b	48.5 ^a
	Cubes	44.4 ^c	50.0 ^c	43.8 ^d	36.5 ^d	36.5 ^b	38.6 ^b
Effect	<i>F</i>	194.56	103.53	196.77	92.88	16.34	6.58
	<i>df</i> [^]	3.57	3.08	3.47	3.28	3.44	3.39
	<i>p</i>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Two values in the same column sharing the same letter did not differ significantly. *N* = 240; SEMs were between 1.3 and 2.3; *p* < .05; 100-mm visual analogue scale. [^] The degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity.

FIGURE 1.5 Data from [Elzerman et al. \(2015\)](#) showing how five different meat substitute ingredients (first column) were judged for their appropriateness for use in six different meals (top row).

still rely on the imagination of the individual and his/her capacity to mentally “place” him- or herself into the depicted context. In a study by [Kim, Lee, and Kim \(2016\)](#), contexts evoked by written consumption scenarios were not found to be as effective in mimicking “real-world” results as was the manipulation of the testing environment itself. This finding is not unexpected, insofar as actual environmental manipulations should logically be more vivid than imagined manipulations.

It is from the efforts to create better “evoked contexts” that researchers have now begun to use pictorial, graphic, auditory, and other multimodal stimuli to establish more realistic contexts in the laboratory ([Dibb-Smith & Brindal, 2015](#); [Elzerman et al., 2011, 2015](#); [Giacalone et al., 2015](#); [Hersleth et al., 2015](#); [Köster, 2003](#)). In addition, more immersive contexts, in which spatial environments are created that better mimic real-life situations, are under way, e.g., using 2D video displays ([Sester et al., 2013](#)), audio recordings, or even aroma stimuli ([Bangcuvo et al., 2015](#)). A variety of these approaches and their applications to food were presented as part of a European Sensory Network workshop on immersive tools at the 2016 EuroSense Conference in Dijon, France ([Porcherot, Kremer, Dreyfuss, & Almi, 2016](#)), including demonstrations of head-worn 3D virtual reality goggles to augment the realism of lab-based contexts. These methods, while producing better imagery and immersion into the intended contextual situation, do suffer from the awareness of the participant that he/she is wearing a head-worn device, as well as a number of commonly reported “virtual reality induced symptoms and effects” that can range from mild disorientation to nausea ([Sharples, Cobb, Moody, & Wilson, 2008](#)). However, it should be noted that such adverse effects are greatly mitigated with the use of desktop and virtual reality theater viewing ([Sharples et al., 2008](#)). As the optics and human-factors elements used in 3D immersive environments improve, so too will the external validity of the obtained data.

3. CONTEXTUAL EFFECTS WITHIN THE INFORMATION ENVIRONMENT

There are many extrinsic contextual factors that arise from elements external to the product, and these extrinsic environmental factors often operate within the information environment of the product. This information environment is created by a variety of external elements, including the product’s name, product, health and nutrition labels, advertising, and a host of other elements that can provide information to the consumer about the product and its likely qualities.

[Fig. 1.6](#) shows a model of how information about a product is processed and integrated to influence consumer behavior ([Cardello & Wright, 2010](#)). Beginning with the source of the information (top left corner of [Fig. 1.6](#)), the information is perceived and then passed through a number of cognitive filters to reach conscious awareness (top right corner).

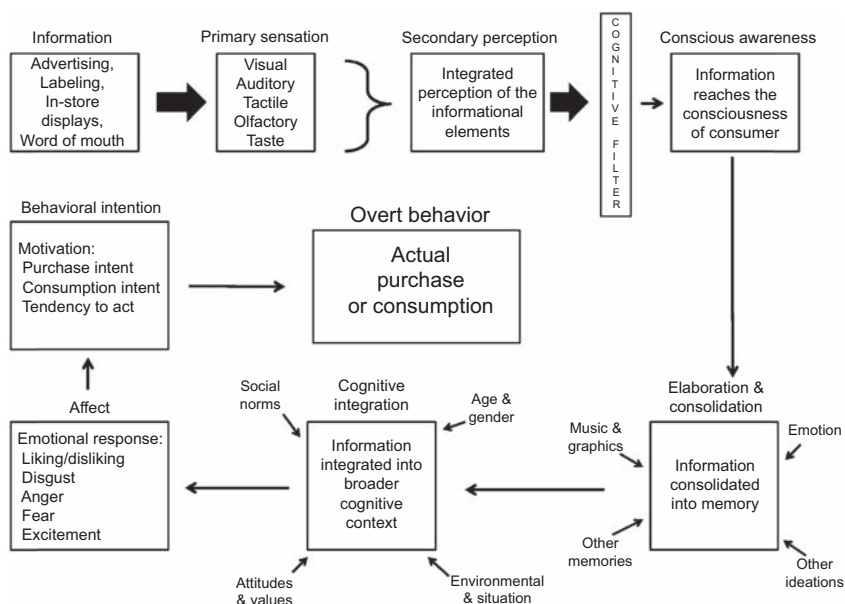


FIGURE 1.6 A model of information processing for foods. (From Cardello, A. V., & Wright, A. O. (2010). *Issues and methods in consumer-led development of foods processed by innovative technologies*. Novel food processing: effects on rheological and functional properties (pp. 337–371). Boca Raton, Fla.: CRC Press, Taylor & Francis Group.)

After conscious awareness, the information is elaborated and consolidated (lower right corner), often through accompanying graphics, pictorial information, and music, each of which aids in enhancing product information by making use of associations formed between images or sounds and other ideations and affective experiences. After this, the information combines with other forms of contextual information, both those extrinsic to the product and those that are intrinsic and specific to the individual receiving the information, e.g., age, gender, or previously formed attitudes and beliefs about the product. Here, the social norms of importance to the individual also alter the nature and importance of the information and its likely impact on behavior (see [Herr, 1989](#); [LaTour & Manrai, 1989](#); [Yi, 1990](#)). After or simultaneous with this stage of integration, affect formation occurs (lower left corner). It is at this point that affect toward the product can be measured, which is followed by the formation of a behavioral intention and, last, overt behavior (choice, purchase, consumption).

3.1 Contextual Effects of Information Influencing Sensory Judgments

In one of the first studies of the effect of information on sensory perception, [Olson and Dover \(1976\)](#) demonstrated that subjects who were simply informed

that a test sample of coffee would have “no bitterness” rated the bitterness of the coffee in a taste test as less intense than subjects who were not provided this information. In a similar study examining the bitterness of pomegranate juice, [Cardello and Sawyer \(1992\)](#) demonstrated that information that the product had “no bitterness,” had “average bitterness,” or was “very bitter” resulted in corresponding changes in the perceived bitterness of the product. Furthermore, these changes were accompanied by changes in judgments of other sensory properties, i.e., the sweetness, astringency, sourness, and degree of fruit flavor of the juice.

Other investigators have examined the effect of product and health-related information on the sensory perception of food. For example, [Levin and Gaeth \(1988\)](#) used the labels “25% fat” or “75% lean” to describe ground beef and found this label information to affect perceptions of the fattiness and greasiness of the tasted samples in the direction suggested by the labels. Similarly, in a series of papers by [Tuorila](#) in which foods were labeled as either “fat-free” or “regular,” it was shown that the “fat-free” label significantly affected ratings of the sensory properties of the foods (saltines, pound cake, cheese) in such a way as to reduce the intensity of such attributes as the “flavor,” “color,” “moistness,” and “sweetness” of the products ([Tuorila, Cardello, & Leshner, 1994](#)). Subsequent research by [Kähkönen and Tuorila \(1998\)](#); [Kähkönen, Tuorila, and Rita \(1996\)](#); and [Kähkönen et al. \(1999\)](#) showed similar effects on sensory judgments when information about the regular versus low-fat content of sausages, spreads/margarine, and chocolate was presented.

In one of the most direct demonstrations of how verbal information, as part of the contextual environment in which a stimulus is presented, can influence sensory perception, [Dalton \(1996\)](#) presented an odorant under three different information conditions: (1) natural extract of balsam trees (positive condition), (2) industrial solvent that could produce health or cognitive problems after long-term exposure (negative condition), and (3) a standard odorant used in smell research. Subjects judged the odor’s intensity every minute for 20 min. Although the positive information group (balsam trees) showed typical adaptation to the odorant over time, the negative information group (industrial solvent) first began to adapt, but then the odor intensity began to increase, reaching strong levels by the end of the test. These data are consistent with the notion that positive/negative information about the stimulus is assimilated into the perception of it, making odorants that are believed to be natural to be perceived as less salient (less perceptually intense) than those that are believed to be dangerous.

In similar studies of the effect of contextual information on odor stimuli, [Distel and Hudson \(2001\)](#) demonstrated that the odors of everyday products were experienced as more pleasant and more intense when subjects were given information about the name of the product than when the odor was unidentified. Similarly, [Scharf and Volkmer \(2000\)](#) demonstrated how brand information can influence the perception of odors. They tested two different perfumes at two different concentrations. Subjects first evaluated the fragrances in a blind test. Then in a second session, they evaluated images of four different perfume packages

for “expected” odor attribute intensities and liking of the product represented [package variables included color and brand (“Christian Dior elegance” vs. “TIP woman”)]. In a final session, consumers rated the fragrances when combined with the various packages. Results showed that the brand information influenced the perception of the perfumes. In some cases, the odor judgments were consistent with the brand information (assimilation), while in other cases, the judgments shifted to be less like that communicated by the brand (contrast).

Many other studies have demonstrated how label information can affect the sensory judgments of food and other products. Among these are studies by [Shepherd, Sparks, Bellier, and Raats \(1991\)](#) showing that fat and sugar content labels can affect judgments of sweetness and viscosity; [Iaccarino, Di Monaco, Mincione, Cavella, and Masi \(2006\)](#) showing that information about geographic origin and processing can influence judgments of the spiciness of salami; [Caporale, Policastro, Carlucci, and Monteleone \(2006\)](#) showing that information about the geographic origin of olive oil cultivars affects perceptions of the bitterness and pungency of the tasted oils; [Okamoto et al. \(2009\)](#) showing that food labels (vs. numeric labels) increase the judged sensory intensity of basic tastants; [Shankar, Levitan, Prescott, and Spence \(2009\)](#) showing that chocolate labeled as “dark chocolate” is perceived more “chocolatey” than when labeled as “milk chocolate”; and [Schouteten et al. \(2015\)](#) showing that a “light” or “reduced-salt” label on cheese reduces perceived fat and perceived saltiness of the cheese.

3.2 Contextual Effects of Information Influencing Affective Judgments

Many of the previous studies that examined information effects on sensory perception also examined their effect on affective judgments of the food ([Caporale et al., 2006](#); [Iaccarino et al., 2006](#); [Levin & Gaeth, 1988](#); [Okamoto et al., 2009](#); [Schouteten et al., 2015](#); [Tuorila et al., 1994](#)). In fact, studies of the effect of information on judgments of liking/disliking and other hedonic variables go back to the earliest days of sensory evaluation. Among these studies were those demonstrating (1) that information about the cost of a food item affected judged liking of food names ([Benson & Peryam, 1958](#)), (2) that ingredient, quality, and processing information affected preferences for tomato juice ([Pettit, 1958](#)), and (3) that brand information affected preference for roasted turkey samples ([Makens, 1965](#)).

However, one study by [Carlsmith and Aronson \(1963\)](#) on the effect of information on sensory judgments of bitter and sweet stimuli led to a major refocus on the important effects of information on the hedonic experience of food and ignited a number of important theoretical developments in our understanding of how information affects food liking. In this study, a series of sweet and bitter solutions was presented to consumers who evaluated them for overall taste intensity. However, before presenting each solution, the experimenters gave the

subjects information indicating whether a bitter or a sweet stimulus would be presented. In some cases this information was accurate, but in other cases, it was misleading, e.g., information that a sweet solution would be presented was given prior to a bitter solution being presented. Results of the study showed that sweet solutions that were preceded by information indicating that the stimulus would be bitter were rated *less* intense than when the preceding information indicated that a sweet stimulus would be presented. Conversely, bitter solutions preceded by information that a sweet solution would be presented were rated *more* intense. In both cases, the false information produced a more negative experience (less sweet or more bitter). To explain their findings, the investigators relied on cognitive dissonance theory (Festinger, 1957), which proposed that when cognitions (beliefs, values, attitudes, perceptions) or behaviors are inconsistent with one another, a negative psychological state of “dissonance” occurs that results in the individual evaluating the stimulus more negatively.

This turn toward an explanation of the results in terms of affective theory led other investigators to search for other intervening variables that could explain a much broader range of results. This search began with Festinger’s own proposition that “the simplest definition of dissonance can, perhaps, be given in terms of *expectations*” (Festinger, 1962, p. 94) and that when expectations are disconfirmed, “a person can change his opinion; he can change his behavior; he can even distort his perception and his information about the world around him” (Festinger, 1962, pp. 93–94). This line of reasoning led to the notion that any stimulus, event, or belief that has the effect of creating an expectation about another stimulus can have an influence on the perception of that stimulus and, in turn, change one’s attitudes or behaviors toward it. This identification of expectations as a potential mediating variable for the important effects of information on consumer behavior led consumer researchers to develop a number of “expectancy–value” models to explain these effects, culminating in what is now known as the “assimilation–contrast model of disconfirmed expectations” (Oliver, 1977, 1980; Olshavsky & Miller, 1972; Olson & Dover, 1976, 1979; Sherif & Hovland, 1961). This theoretical model, which is now well known among sensory and consumer researchers, states that under most circumstances, a discrepancy between expectations and product experience will cause product ratings to move in the direction of the expectation (assimilation). However, when the product differs greatly from its expected value, the product experience will move away from its expected value (contrast). The reader should see Oliver (1977, 1980), Cardello (1994, 2007), and Deliza and MacFie (1996) for detailed reviews and discussions of these theories and their implications for food-related behavior.

In a series of papers and book chapters, Cardello et al. (Cardello, 1994, 1995, pp. 177–201; Cardello, Maller, Masor, Dubose, & Edelman, 1985; Cardello et al., 1996; Cardello & Sawyer, 1992) began to use the concept of expectations as a mediating variable to explain the effects of a wide variety of contextual effects created by information contained in product names, labels, packaging,

serving vessels, product and process information, etc. This work was soon followed by a number of other research efforts in this area (Deliza, 1996; Deliza & MacFie, 1996; Schifferstein, 1996; Schifferstein, Kole, & Mojet, 1999), all of which focused attention on the role of disconfirmed expectations as a mediating variable to explain changes in product perception, liking, and associated variables as a consequence of the contextual environment in which the food product was presented.

Over the years, numerous studies have been undertaken on such important informational elements as simple product names (Cardello & Sawyer, 1992; Yeomans, Chambers, Blumenthal, & Blake, 2008), nutrition labels (Fernqvist & Ekelund, 2014; Kähkönen & Tuorila, 1995; Kähkönen et al., 1996; Kähkönen et al., 1999; Kähkönen, Tuorila, & Lawless, 1997; Norton, Fryer, & Parkinson, 2013; Tarancón, Sanz, Fiszman, & Tárrega, 2014; Tuorila & Cardello, 2002; Tuorila, Andersson, Martikainen, & Salovaara, 1998; Tuorila et al., 1994; Vázquez, Curia, & Hough, 2009; Wansink, Park, Sonka, & Morganosky, 2000; Wardle & Solomons, 1994), geographic origins of the food (Caporale et al., 2006; Stefani, Romano, & Cavicchi, 2006), or the methods of processing and preserving it (Caporale & Monteleone, 2004; Cardello, 2003; de Carniero et al., 2005; Iaccarino et al., 2006; Siret & Issanchou, 2000). In some cases simple sensory information, e.g., visual or taste, has been examined for its effect on liking (Hurling & Shepherd, 2003; Lange, Issanchou, & Combris, 2000; Siret & Issanchou, 2000). In other cases, health-related information has been examined for its effects on expectations, choice, or consumption (Ares, Giménez, & Deliza, 2010; Bowen, Tomoyasu, Anderson, Carney, & Kristal, 1992; Cavanagh & Forestell, 2013; Provencher, Polivy, & Herman, 2009; Wansink & Chandon, 2006).

In the majority of the above studies, assimilation of the ratings in the direction of expectations has been found. However, contrast has also been demonstrated in a number of cases, especially where, in line with theoretical predictions, the discrepancy between expected and actual product characteristics is large or salient from a sensory perspective (Cardello & Sawyer, 1992; Davidenko et al., 2015; Kuenzel, Zandstra, El Deredy, Blanchette, & Thomas, 2011; Yeomans et al., 2008).

Fig. 1.7 shows data from an interesting study by Yeomans et al. (2008), looking at the effects of information and consumer expectations on product perception and liking. In this study a novel, smoked salmon–flavored ice cream was used as the test sample. In one condition, the product was labeled as “ice cream,” a label that would normally generate a positive expectation for the product. In the other condition, the product was labeled as a “frozen savory mousse,” a label likely to generate a less positive expectation. When the product was labeled as “ice cream,” it was perceived to have a stronger flavor, more bitterness and saltiness, and was rated as being far less pleasant than when the product was labeled as a “frozen savory mousse” (Fig. 1.7). The data can be interpreted as showing that the “frozen savory mousse” label generated an expectation that was more in keeping with the actual taste of the

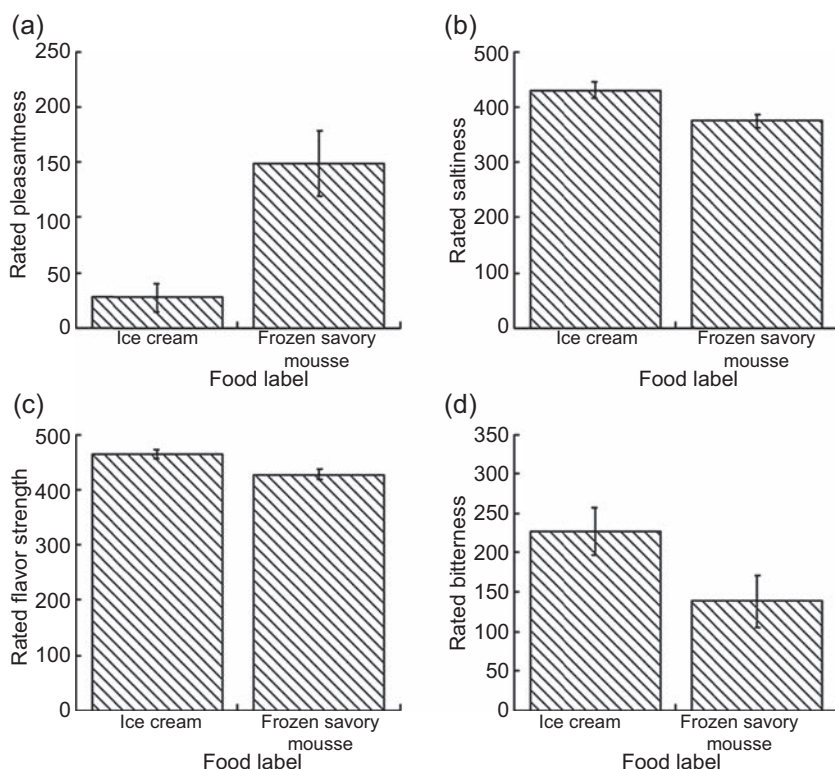


FIGURE 1.7 Data from [Yeomans et al. \(2008\)](#) showing the effect of information from alternative food labels/names (either “ice cream” or “salmon-flavored mousse”) and their effects on judged pleasantness (a), saltiness (b), flavor strength (c), and bitterness (d) of the same test product (salmon-flavored ice cream).

product, but that the “ice cream” label produced a positive expectation that was disconfirmed by the product, producing ratings that were much lower in pleasantness (i.e., a contrast effect).

Contrast effects are somewhat counterintuitive in the sense that a positive expectation results in lowered liking for a product, while a negative expectation produces greater liking. Such counterintuitive effects have also been found in studies of the effect of health labels on consumption. For example, although [Provencher et al. \(2009\)](#) showed that the label “healthy,” when ascribed to cookie ingredients, increased the consumption of the cookies over those that were ascribed to be made with “unhealthy” ingredients, and [Cavanagh and Forestell \(2013\)](#) showed that “healthy” brand labels increased consumption among restrained eaters, other researchers have shown opposite and counterintuitive effects. In one of these studies, [Bowen et al. \(1992\)](#) showed that ice cream labeled as “high fat” increased consumption over ice cream labeled as “low fat.” Similarly, [Wansink and Chandon \(2006\)](#) showed that low-fat labels increased consumption of a variety of snack foods. These counterintuitive results led the

latter investigators to argue that healthy labels may increase consumption by releasing consumers' inhibitions about eating unhealthy foods (Wansink & Chandon, 2006).

Portion size information can also have counterintuitive effects on consumption. Some studies have shown no effect of portion size information on consumption (Ueland, Cardello, Merrill, & Leshner, 2009), while others have shown that increasing portion size information decreases consumption. For example, Aydinoglu and Krishna (2010) showed that labeling cookie portions as being "large" compared to "medium" reduced the total number of cookies eaten. Similarly, larger portion size information about pizza servings reduced total consumption relative to smaller portion size information (Spanos, Kenda, & Vartanian, 2015). Thus, just as Wansink and Chandon (2006) have shown that "healthy" labels can increase consumption, Reily and Vartanian (2016), in a review of studies on the effect of portion size, have concluded that "contextual size information that reduces the perceived size of the portion can lead to increased consumption, and contextual size information that amplifies the perceived size of the portion can lead to decreased consumption." (See further discussion of portion size effects attributable to plate size in Section 4.2.3.)

Piqueras-Fiszman and Spence (2015) conducted an extensive review of all of the research that has manipulated the information context for foods. In their review they divide this research into effects due to "linguistic" information and effects due to "pictorial" information. Further, they divide linguistic informational cues into four categories: names and sensory descriptions, labels and product/growing processes, health and ingredient labels, and ethnicity of the food. The reader is directed to this excellent review to find the many cases whereby the different contextual elements in a food environment can operate through information channels and consumer expectations to influence product judgments. The reader is also directed to a 2016 review of methods for combining sensory and extrinsic (e.g., informational) elements in consumer studies (Asioli, Næs, Øvrum, & Almli, 2016).

In summary, the information that accompanies foods can alter perception, liking, choice, and consumption of the food in both expected and unexpected ways—a fact that might well be predicted from the complexity and number of variables that interact with one another in the processing of information prior to it having an impact on hedonics and behavior.

4. CONTEXTUAL EFFECTS WITHIN THE PHYSICAL ENVIRONMENT

4.1 Effects of Packaging

As noted previously, especially influential in food choice behavior are pictorial and photographic representations on the labels or packages of products (Jaeger & MacFie, 2001), because they provide direct information about the product's

likely color, shape, size, and sensory properties. In early research at the Natick RD&E Center investigating the role of packaging on product liking, identical food items were examined when they were packaged in either drab military packages or more customary commercial packages. Consumers in three separate studies using different food items were found to rate their liking for the products higher when they were presented in the commercial packages than in the military packages (Cardello & Bell, 1995; Cardello et al., 1985; Kalick, 1992). Insofar as information on the packages was not deliberately manipulated in these studies, it appears that other, contextual elements associated with the colors, letter fonts, and designs on the packages established an impression of higher quality for the products in the commercial packages, which translated into higher acceptance ratings through a process of assimilation. Deliza, MacFie, and Hedderley (2003) also examined the influence of packaging variables (background color, picture, information, brand, language, and shape) on liking for passion fruit juice using a conjoint analytic design. They found significant effects on judgments of the sweetness, pureness, sharpness, refresh- ingness, freshness, naturalness, and liking of the juice, with the background color and information on the package being the most important drivers of these effects. In their review of various forms of extrinsic product cues on sensory and hedonic expectations toward food, Piqueras-Fiszman and Spence (2015) also highlighted the importance of visual elements and symbols, including colors and graphics, for establishing consumer expectations and influencing sensory and hedonic perception. Among the studies and papers showing the effects of both pictures and packaging variables on sensory and hedonic prop- erties of products are those by Ares and Deliza (2010); Mizutani et al. (2010); Ares et al. (2011); Piqueras-Fiszman, Ares, and Varela, 2011; Piqueras-Fiszman and Spence (2011a); as well as earlier studies by Bone and France (2001) and Sakai, Imada, Saito, Kobayakawa, and Deguchi (2005). The contextual effects that occur in many of these cases have been attributed to cross-modal associa- tions and correspondences between specific package elements and correspond- ing perceptual attributes, e.g., the finding that round shapes are associated with sweetness and angular shapes correspond with sour tastes (Ngo et al., 2013) or that certain typefaces (e.g., rounder ones) are associated with specific sensory properties (e.g., sweetness) (Velasco, Salgado-Montejo, Marmolejo-Ramos, & Spence, 2014). These and other forms of cross-modal correspondences that can occur as a result of differences in packaging elements were reviewed by Velasco, Woods, Petit, Cheok, and Spence (2016).

4.2 Effects of the Color, Shape, Size, and Appropriateness of the Serving Vessel

4.2.1 Appropriateness of the Serving Vessel

The previous contextual effects of food packaging can easily be extrapolated to serving vessels. In the same way that different elements of a food package

can influence the sensory, hedonic, and conative properties of a food item in a grocery store, so too can the color, shape, and size of a serving vessel serve as a source of contextual cues that can influence expectations and sensory/affective judgments of foods served in a restaurant or at home. In the paper cited earlier, in which military and commercial packages were interchanged to show effects on product liking (Cardello et al., 1985), serving vessels for liquid foods (soup vs. dental liquid foods) were manipulated to match or mismatch the typical manner in which the foods would be presented (bowl and spoon vs. glass and straw). Significant effects were observed on liking, such that the foods were rated higher when presented in their appropriate vessel. The notion that a container or serving vessel must be appropriate to the food it contains was also investigated by Raudenbush, Meyer, Eppich, Corley, and Petterson (2002), who demonstrated that beverages served in an appropriate drinking container (i.e., hot chocolate served in a ceramic cup) rate higher for pleasantness than when served in an inappropriate vessel (i.e., hot chocolate in a glass or bottle).

4.2.2 *Color of the Serving Vessel*

In early research on the color of the serving vessel, Cheskin (1957) showed that 7-Up was rated more intense in lemon/lime flavor when the beverage was served in a can that was more yellow in color. Similarly, wine served in red glasses has been shown to be rated differentially, even by wine experts, than wine served in clear glasses (Williams, Langron, & Noble, 1984). More recently, Harrar, Piqueras-Fiszman, and Spence (2011) showed that the color of the serving bowl can affect the taste of popcorn, while Piqueras-Fiszman, Alcaide, Roura, and Spence (2012) showed that white plates (vs. black) enhanced the sweetness and liking of a strawberry mouse. Piqueras-Fiszman and Spence (2012) demonstrated that presenting a hot chocolate beverage in a white, red, orange, or dark cream-colored plastic cup can affect the perceived odor and taste of the chocolate, with the cream-colored cup enhancing sweetness and chocolate aroma. In a related study on coffee, coffee flavor intensity was greater and sweetness lower when coffee was served in a white versus a clear mug (van Doorn, Willemin, & Spence, 2014), and the color of the cup can even influence the perceived warmth of the beverage, with coffee in a red cup being perceived as warmer than coffee in yellow, green, or blue cups (Guéguen and Jacob, 2014). In all these cases, there is an indication that the color of the cup enhances perceptions that are consistent with that color in terms of its natural associations with the attribute (yellow–lemon/lime, cream color–sweet, red–hot, etc.).

Similar associations have been observed for cold drinks. For example, Schifferstein (2009) demonstrated that soda drinks presented in pink cups were rated sweeter than when presented in clear cups, and Guéguen (2003) demonstrated that soda drinks were perceived as more thirst-quenching when served in blue glasses versus green or red—blue being normally associated with “cold,” an allied thirst-quenching attribute.

4.2.3 Shape, Size, Weight, and Feel of the Serving Vessel

A large number of other physical aspects of the vessels in which foods are served can produce contextual effects on the perception of those foods (see [Spence, Piqueras-Fiszman, Michel, & Deroy, 2014](#), for a review). Thus, in a similar vein to the studies looking at the effect of the color of a coffee mug on the perceived flavor of the coffee, [van Doorn et al. \(2017\)](#) has looked at the effects of the shape of coffee mugs on expectations about their likely flavor properties. Among the findings from an online survey of different coffee mug shapes, these investigators found that coffee was expected to be more aromatic in narrower mugs, more bitter and intense in shorter mugs, and sweeter in wider-diameter mugs ([van Doorn et al., 2017](#)).

In several studies that actually varied the shape of glasses being used to consume wine, important effects have been shown on judgments of both the sensory and the hedonic ratings of the wine contained in the glasses ([Cliff, 2001](#); [Hummel, Delwiche, Schmidt, & Hüttenbrink, 2003](#); [Vilanova, Vidal, & Cortés, 2008](#)). These studies showed that the shape of the wine glass affected the rated intensity of its odor, such that wines served in a bowl-shaped glass were rated higher in aroma than those served in tulip-shaped or egg-shaped glasses ([Cliff, 2001](#)), as were wines served in bulb-shaped (vs. e.g., V-shaped or tulip-shaped glasses) ([Hummel et al., 2003](#); [Vilanova et al., 2008](#)). [Spence \(2011b\)](#) has analyzed these studies relative to others that have failed to find effects of glass shape on wine ratings ([Delwiche & Pelchat, 2002](#); [Russell, Zivanovic, Morris, Penfield, & Weiss, 2005](#)) and has concluded that a critical difference in the studies is whether the subject actually handles the glass versus simply tasting/smelling from it. Effects of glass shape occur only in those cases where subjects actually handle the glasses, leading [Spence \(2011a\)](#) to conclude that the effects are psychological in nature and not related to differences in how the volatiles or liquid interact with the nose/mouth when served in the different glasses.

The size, weight, and feel of the serving vessel are other contextual variables that can influence consumers. However, in the case of serving vessel size, rather than having an effect on perceived or hedonic aspects of the food, serving size has been shown to have a profound effect on behavior, specifically, on consumption behavior. In a series of studies and papers, [Wansink \(Wansink, 1996, 2004; Wansink & Cheney, 2005; Wansink, van Ittersum, & Painter, 2006; Wansink & Kim, 2005\)](#) has shown that the larger the serving vessel in which foods are served, the larger is the total consumption of that food item. This “portion size effect” has been demonstrated by numerous investigators, and a number of reviews have examined its influence on intake ([Benton, 2015](#); [English, Lasschuijt, & Keller, 2015](#); [Herman, Polivy, Vartanian, & Pliner, 2016](#)). In a 2016 study, [Reily and Vartanian \(2016\)](#) tested the portion size effect against the effect of contextual size information, by presenting consumers with small or large portions of pizza accompanied by contextual size information that the portion was either small large or no information. Results showed that the portion

size effect was more powerful than the contextual size information effect, and interestingly, they found that the participants' perceptions of how much was "appropriate" to eat mediated the effects of portion size on intake.

With regard to the weight of serving vessels, Lindstrom (2005) argued that the weight of foods and other consumer products is often associated with perceptions of quality or higher price, and Piqueras-Fiszman, Harrar, Alcaide, and Spence (2011) demonstrated that heavier bowls generated significantly greater ratings of the perceived density, expected price, and liking of yogurts served in the bowls. A similar effect has been demonstrated with a heavy stainless steel spoon versus a lighter plastic spoon when eating yogurt from a bowl (Fig. 1.8, top) (Piqueras-Fiszman & Spence, 2011b). The results of the study (Fig. 1.8, bottom)

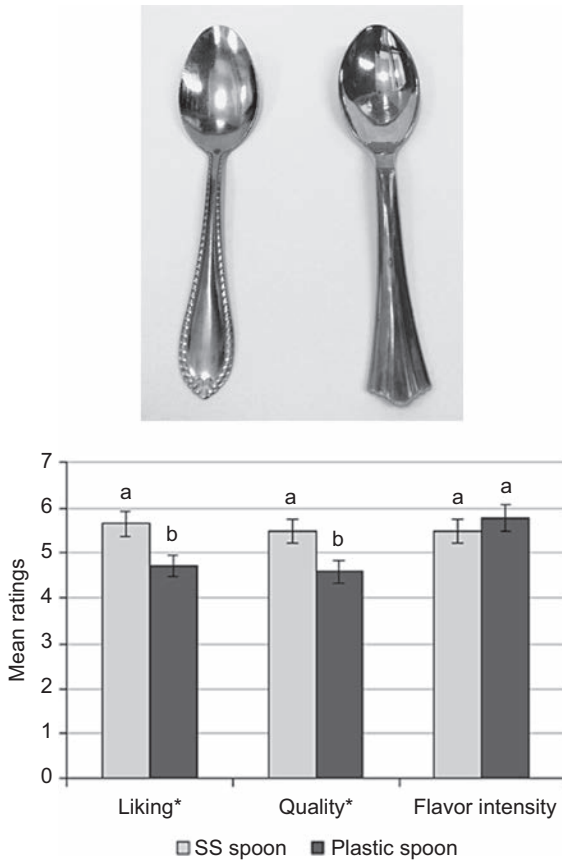


FIGURE 1.8 The two spoons, either heavy stainless steel (*left*) or a lighter metallic-plastic spoon (*right*), used in a study in which consumers ate yogurt served from a bowl using one of the two spoons (*top*) and the data from that study showing how the liking, quality, and flavor intensity of the yogurt varied depending on the spoon that was used (*bottom*). (From Piqueras-Fiszman, B., & Spence, C. (2011b). *Do the material properties of cutlery affect the perception of the food you eat? An exploratory study*. Journal of sensory studies, 26(5), 358–362.)

show that both the quality of the food and subjects' liking for it was increased when the heavier metallic spoon was used versus the lighter, plastic spoon. Although weight and material/design of the spoon were necessarily confounded, it can well be argued that a spoon that is heavier and/or of higher perceived quality is likely to set higher expectations for the product being consumed, which can, in turn, affect actual perception and liking of it.

The conclusion of all of this research was summarized in a 2015 review of the field by [Spence and Wan \(2015\)](#), who concluded that the combined results of multiple studies demonstrate a profound impact of the drinking vessel/receptacle on the perception of beverages. Further to this point is the fact that the natural associations with, and the appropriateness of, the serving vessel's shape and color for the perceived sensory attributes of the food/beverage are important elements in the final perception of them ([Ngo, Piqueras-Fiszman, & Spence, 2012](#), [Ngo et al., 2013](#)) and that many of these associations are culturally determined ([Wan, Woods, Butcher, Seoul, & Spence, 2015](#)).

4.3 Effects of Lighting and Music

Although the contextual effects of a variety of physical aspects of the environment have been examined in the laboratory, of late there has been interest in looking at more complex, environmental variables that operate in real-world situations but that can still be examined in a laboratory setting. Among these are lighting and music. However, it must be kept in mind that most contextual studies of lighting and music occur in naturalistic settings, so the studies cited here are relatively few in number.

With regard to lighting, it has been shown that dim or dark lighting can increase the amount that individuals consume, perhaps due to a degraded ability to self-monitor the amounts consumed ([Kasof, 2002](#); [Scheibehenne, Todd, & Wansink, 2010](#); [Wansink & van Ittersum, 2012](#)). However, in a laboratory study in which consumers tested food samples either under normal lighting conditions or in the dark, it was shown that while familiar foods appear to be unaffected by lighting, unfamiliar foods eaten in the dark are less well liked, perhaps due to the uncertainty that accompanies consumption of unknown foods in the dark ([Wansink, Shimizu, Cardello, & Wright, 2012](#)). With regard to sensory effects, basic taste research has shown that both the total light intensity (illumination level) and the color temperature (warm vs. cool) can influence salivary rate and taste thresholds ([Katsuura, Jin, Baba, Shimomura, & Iwanaga, 2005](#)). Other research on cool versus warm lighting in the assessment of packaged foods has shown that food is rated to be less attractive and of lower quality and less likely taste acceptance when presented in cool light versus warm light ([Otterbring, Löfgren, & Lestelius, 2014](#)). And in a direct test of the color of ambient lighting on the evaluation of wines, it was shown that (1) the perceived spiciness of Riesling wines was greater under blue and green lights than under red or white lights, (2) the bitterness of these wines was greater under blue versus either green or white lights, and (3) there was a marginally significant and opposite

effect (to 2 above) for fruitiness judgments (Oberfeld, Hecht, Allendorf, & Wickelmaier, 2009). However, no effects were observed on odor ratings of the wines. In a subsequent test using both rating and choice methodologies, these same investigators found the wines to be judged sweeter under red versus blue or white lighting and, based on the choice data, concluded that these wines were judged to be fruitier under red than blue lighting (Oberfeld et al., 2009).

With regard to music, it has been reported that loud music increases consumption rates and the total amount of food consumed (McCarron & Tierney, 1989; Stroebele & de Castro, 2006; Wansink & van Ittersum, 2012), but quieter, more appealing music has also been shown to increase consumption by increasing the total amount of time spent eating (Caldwell & Hibbert, 2002; Milliman, 1986). From a sensory perspective, loud music has been shown to increase the pleasure from sucrose (Ferber & Cabanac, 1987), despite the fact that when musicians are asked to compose music that is “sweet,” the compositions are slow, soft, and consonant (Mesz, Trevisan, & Sigman, 2011). In a 2012 laboratory study, Crisinel et al. (2012) demonstrated that differences in music could lead to differences in the evaluation of the sensory properties of bitterness and sweetness in foods. In particular, these investigators created and pilot-tested two soundtracks—one that was associated with bitter tastes and one that was associated with sweet tastes. They then played these soundtracks while consumers were evaluating different toffee products and found that the soundtrack associated with bitter taste resulted in greater bitterness ratings of the test toffee, while the soundtrack associated with sweet taste produced higher sweetness ratings in these products.

In a more direct test of the influence of the genre of ambient music on food ratings, consumers rated the pleasantness of chocolate to be greater when tasted while jazz music was playing in the background versus when hip-hop music was playing (Fiegel, Meullenet, Harrington, Humble, & Seo, 2014). Of course, the effect of different genres may well be due to the personal preferences of consumers for those specific music genres. In several studies, Kantono et al. (2015, 2016) have shown that music that is deemed to be pleasant by listeners increases liking for foods relative to music that is found to be unpleasant. In addition to its pleasantness, the appropriateness of the music may also have a role, e.g., in several studies it has been shown that playing ethnically appropriate (vs. inappropriate) music can increase the choice of ethnically congruent foods versus foods of other ethnic origins (North, Hargreaves, & McKendrick, 1997, 1999; Zellner, Geller, Lyons, Pyper, & Riaz, 2017).

5. CONTEXTUAL EFFECTS WITHIN THE MEAL ENVIRONMENT

When foods are presented for consumption in real-life consumption situations, there is often more than one choice of food. Hayes, DePasquale, and Moser (2011) have shown that characteristics of this choice set can influence consumer preferences for individual items in the set. Similarly, among the foods

to be eaten at a meal, there is often more than one food item present on the plate. These other foods can have a significant influence on judgments and behavior toward any item. Thus, it has been known for some time that increasing the variety of flavors of a food item, e.g., yogurt, can increase the amount of yogurt consumed (Rolls et al., 1981). Moreover, it has been shown that not just the total variety but also the structure of the assortment (e.g., an organized or symmetrical assortment vs. a disorganized or asymmetrical assortment) can affect the amount consumed (Kahn & Wansink, 2004). That is, the general symmetry or attractiveness of the various foods presented to consumers can affect their overall perception of the food and their behaviors (choice, consumption) toward it (see Deroy, Michel, Piqueras-Fiszman, & Spence, 2014 for a discussion). Zellner, Lankford, Ambrose, and Locher (2010), Zellner et al. (2011), and Zellner, Loss, Zearfoss, and Remolina (2014), for example, have shown that both the balance and the complexity of the foods served on a plate can affect the attractiveness, willingness to try, and liking of the foods. In one study, these investigators simply manipulated the balance of the foods on a plate to improve the attractiveness of the foods. When consumers were presented with these foods in the two different configurations, they perceived the balanced configuration to be more attractive and had an increased willingness to try the food. However, there was no effect on liking (Zellner et al., 2010). In a related study, Zellner et al. (2011) again manipulated the balance and arrangement of foods on a plate. In this study, they used multiple arrangements. Fig. 1.9 shows the balanced–unbalanced arrangements (Fig. 1.9; top–balanced, bottom–unbalanced). Another arrangement simply manipulated whether the food was presented in a neat or messy arrangement. When consumers were presented with the arrangements, they rated the perceived quality of the food and their liking for the balanced and neat presentations higher and had an increased willingness to pay for the food (Zellner et al., 2011). Further, in a more recent study, they were able to demonstrate that a more attractive arrangement of foods on a serving plate can increase liking for the majority of foods on the plate (Zellner et al., 2014), a fact that has been confirmed by Michel, Velasco, Gatti, and Spence (2014) using art-inspired plating arrangements. Interestingly, in the Zellner et al. (2014) study, it was the side vegetable that was unaffected by the more attractive arrangement.

The role of the different components of a meal (side dish vs. entrée vs. dessert, etc.) in the rating of the overall meal was studied early on by Eindhoven and Peryam (1959) and Moskowitz and Klarman (1977), who showed that two items, even if they are both well liked (e.g., lasagna and cole slaw), that are perceived to be incompatible together in a meal will both be rated lower in acceptance than either one rated alone. While these data are interesting, it is rarely the case that incompatible food items are presented together in a real-life consumption situation. However, in a 2015 study (Jimenez et al., 2015), the effect of compatible items presented together on a plate was investigated to determine how the liking of some components could affect liking for other components. In this study, a control

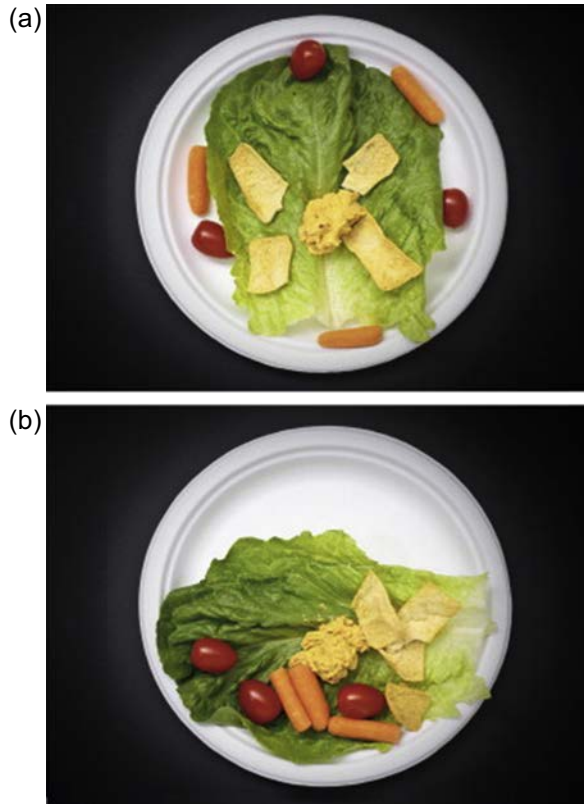


FIGURE 1.9 The balanced/neat (a) and unbalanced/messy (b) arrangements of foods used in the study by [Zellner et al. \(2011\)](#), in which consumers rated the perceived quality of the food and their liking for the balanced/neat presentations higher and had an increased willingness to pay for it.

main dish consisting of a chicken tender was presented on a plate, along with either two well-liked side dishes (corn and mashed potatoes) or two less-liked side dishes (beets and lima beans). When the ratings of liking for the control main dish were compared, it was found that the main dish was rated as being less liked when paired with the well-liked side dishes and more liked when presented with the disliked side dishes, a classic example of a hedonic contrast effect. However, from the point of view of being able to conduct laboratory studies of contextual effects using evoked situations, it is interesting that no effects of context were found when only pictures of the plated foods were presented ([Jiminez et al., 2015](#)).

6. SUMMARY OF LAB-BASED RESEARCH ON CONTEXT

As can be seen in the wide variety of contextual effects on food perception and liking that have been reviewed, the role of lab-based studies in identifying potentially important contextual variables is extremely important, despite

concerns about its external validity. The sheer number and types of effects that have been observed, documented, and replicated speak for themselves. As seen here, the contextual effects that have been demonstrated range from those that occur between two items on a plate to the extrinsic effects of information, the physical effects of packages and serving vessels, and the contextual influences among foods within the same meal. In addition, lab-based research has begun to expand its ability to mimic real-life eating occasions through the use of various forms of evoked contexts, using visual, auditory, and other sensory modalities to better “place” the individual into the target context. Last, the developments in new, 3D immersive technologies offer the hope that more realistic lab-based testing of foods within a simulated contextual environment can vastly improve the extrinsic validity of lab-based research and, in turn, make the study of contextual variables in real-life situations a more efficient and less costly endeavor than is currently the case.

7. NONLABORATORY (NATURAL) METHODS

It should be noted that natural methods of studying context have far fewer published studies, because as noted before, contextual research comparing different test situations did not begin until well into the 1980s and later.

7.1 Contextual Effects Using Attitudinal and Expectations-Based Methods

[Cardello et al. \(1996\)](#), using field-based surveys, studied the expectations of young US civilian and military consumers regarding the liking and quality of food served in different locations and found that the order of expected liking/quality from highest to lowest was home > sit-down restaurant > fast food restaurant > school > military > airline > hospital). These results are often described as showing an institutional effect, that is, all institutional food locations (school, military, hospital) ranked lower in the expected quality of the served food than noninstitutional locations (home, sit-down restaurant, and fast food restaurant). It appears that airline food is grouped with the institutional food locations. Results such as those of [Cardello et al. \(1996\)](#) on food expectations can be used to understand differences in product acceptance in different physical serving locations (see data of [Edwards, Meiselman, Edwards, and Leshner, 2003](#), presented later).

[Tuorila, Peränen, Uutela, and Jallinoja \(2015\)](#) studied the expectations of institutional food (specifically, army food) among young Finnish men, and found a somewhat different pattern than previously found among soldiers in the US army ([Hirsch, Kramer, & Meiselman, 2005](#); [Meiselman et al., 1988](#); see below) and among US consumers ([Cardello et al., 1996](#)). [Tuorila et al. \(2015\)](#) found no negative expectations of food in Finnish soldiers, but did find that 21 of 36 foods failed to meet their expectations of liking. [Tuorila et al. \(2015\)](#)

argue that the Finnish food experience prior to induction into the army raises the expectation of young Finnish soldiers, but that the Finnish army food does not meet these expectations.

Wansink, van Ittersum, and Painter (2005) compared consumer responses in a university staff cafeteria for foods containing “evocative, descriptive menu names” compared to the same foods with regular names. People chose their own foods. The more descriptive names led to more positive comments. The difference between the more positive and less positive ratings was in the range of 0.5–1.0 scale points, which is the range normally seen in contextual comparisons. The authors conclude that the product evaluations were assimilated with prior product expectations.

7.2 Contextual Effects Within Meal Components

There is history of studying food combinations in natural eating locations, especially in naturally occurring meals. Questionnaire work in the 1980s showed that liking for the main dish is important for meal evaluation, with the main dish accounting for 50% or more of meal acceptance (Rogozenksi & Moskowitz, 1982; Turner & Collison, 1988). Tuorila had noted that in a laboratory experiment in which different combinations of sandwiches and milk were rated, the pleasantness of the sandwich, rather than that of milk, determined the overall pleasantness of the combination (unpublished data from Tuorila, personal communication). Hedderley and Meiselman (1995) studied meal patterns and food combinations in a student cafeteria in the United Kingdom, where students chose their own meal items, rather than following a prescribed pattern of meals. The authors discuss some of the challenges of studying meals when meal size varies, and when there are missing values for some food categories because of the free-choice environment. This contrasts with the ability to hold meal components constant in many laboratory environments.

7.3 Contextual Effects in Natural Field Settings

Contextual research conducted at the US army’s Natick Laboratories from the 1980s to the 2000s was summarized by Hirsch et al. (2005). Contextual research at Natick grew out of longer-term studies of eating than had been conducted previously, including both the study of product hedonics and the amount consumed. In prior tests, a new food product at Natick would be tested in a taste test laboratory with civilians and then with actual soldiers in the field. But these tests were relatively short (days), and there was often access to other food. However, in the mid-1980s the psychology group at Natick was asked to test military packaged meals in an isolated location (the Big Island of Hawaii) for a long period of time (30+ days). This test and the tests that followed changed the perspective of the Natick researchers, and added “context” to their view of what controlled eating, at least by soldiers, and possibly by many other groups. This

TABLE 1.2 Extended Testing of Army Rations: Comparison of Military and University Consumers in Terms of the Duration of the Test, the Average Daily Intake, the Average Weight Change in the Subjects From the Start of the Test to the Finish, and the Average Ratings of the Acceptance of the Food During the Test Period

	Duration	Daily Intake	Weight Change	Acceptance ^a
Army in the field	34 days	2189 kcal	−10.4 lb	7.05
University	44 days	3149 kcal	−1.5 lb	6.05

^a9-pt hedonic scale.
Based on a similar table in: Meiselman, H. L., Hirsch, E. S., & Popper, R. D. Sensory, hedonic and situational factors in food acceptance and consumption. In D. M. H. Thomson (Ed.), *Food Acceptability*, 1988, 77–88.

was initially tested by comparing product ratings and product consumption of the same packaged meal by real soldiers in the field and by students at a university. Even though the soldiers and the students were provided the same food, the students rated the food as less acceptable, but ate 1000 more calories per day; the soldiers rated the food higher, but ate much less of it. The researchers had expected a clear positive relationship between liking and intake. The results of this research are summarized in [Table 1.2](#).

In the following years, this pattern of intake by soldiers was replicated many times, showing that soldiers waste a lot of their food. In fact, the consumption by soldiers did not improve ([Fig. 1.10](#)), although the food was continuously improved over that period, as shown by laboratory sensory testing of food acceptability.

The Natick researchers concluded from their many tests that the environment or context of eating was a critical factor in determining whether food was liked and whether it was consumed.

7.4 Home Testing Versus Lab and Central Location Testing

Another important comparison in contextual testing is the choice of testing location. It is common practice in commercial testing to first test a product either in the laboratory or in a central location test (CLT), and following successful testing, to then test the product in a home use test. There is a very large number of papers in *Appetite*, *Eating Behaviors*, and other journals dealing with (healthy) eating “at home,” but very few papers comparing at-home eating to other settings such as a controlled testing in a laboratory or CLT. Also, the Proceedings of the Oxford Symposium on Food and Cookery 2001 ([Walker, 2002](#)) provides a broad look at meals across many cultures and many time periods.

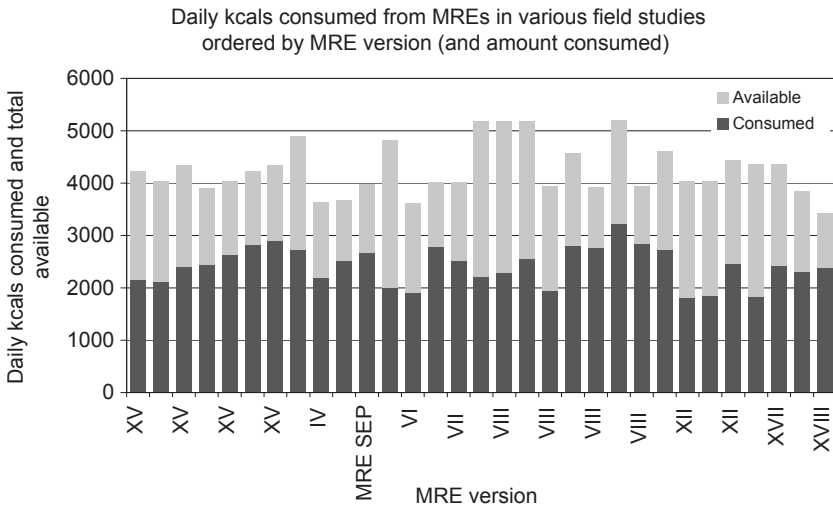


FIGURE 1.10 Daily kcals available in the Meals Ready to Eat (MRE) packed ration (*light line*) and the number of kcals consumed on average (*dark line*) during several military field exercises. The studies are listed by the ration issue number in roman numerals. The most recent ration study/issue appears on the far right (XVIII).

Beginning in 2003 a group at McCormick and Co., Inc., began a series of studies of context comparing the CLT location to other locations and contexts. They showed how adding contextual factors to the basic CLT led to differences in product liking. They tested products with the following variables: (1) whether products were served alone or within a meal, (2) whether products were served to people alone or in social groups, (3) a plain testing environment or a more attractive environment, and (4) whether consumers had a choice of foods. They even tested their products in a local restaurant. Ratings of acceptability showed higher ratings under all conditions compared with the CLT rating, with the restaurant rating being the highest. These contextual effects were confirmed by [Weber, King, and Meiselman \(2004\)](#) and by [King et al. \(2004\)](#) working in a CLT environment and a restaurant environment. In similar studies within the laboratory, [Kim et al. \(2016\)](#) similarly studied coffee consumption in Korea, using both a laboratory location (testing booth) and simulated café settings in the laboratory. Coffee was rated higher in the simulated café setting.

[Kozłowska et al. \(2003\)](#) compared the results of testing apple juice in a sensory laboratory, a university common room, or at home over 5 days. The unsweetened juice scored higher in liking in the home test, but this difference was not seen in the sweetened juices. Overall, [Kozłowska et al. \(2003\)](#) found poor predictability of intake from the laboratory to the home situation, with the common room falling between, and they attributed the laboratory results to brief product exposure time.

Several studies were conducted by Boutrolle and Delarue (see [Delarue & Boutrolle, 2010](#)). Earlier research had noted generally higher liking scores in natural environments compared to CLT or laboratory testing (see [Boutrolle, Arranz, Rogeaux, & Delarue, 2005](#) for a review), but they also noted that most prior tests did not show differences in product rankings between home use tests and laboratory tests or CLTs. [Boutrolle et al. \(2005\)](#) noted that this lack of product differences is an advantage for laboratory or CLT testing.

[Boutrolle, Delarue, Arranz, Rogeaux, and Köster \(2007\)](#) found the same pattern of higher product ratings at home. [Boutrolle et al. \(2007\)](#) notes that “Previous studies also showed that standardised situation tests underestimate product acceptance as compared to tests carried out in natural settings ([Hersleth, Mevik, Næs, & Guinard, 2003](#); [King et al., 2004](#); [Kozłowska et al., 2003](#); [Meiselman et al., 1988](#); [Meiselman, Johnson, Reeve, & Crouch, 2000](#); [Murphy, Clark, & Berglund, 1958](#)). Several differences between CLT and HUT could account for this phenomenon.” [Boutrolle et al. \(2007\)](#) considered several alternative explanations for these effects: (1) the confound of method and panel differences; (2) higher well-being in natural environments, and hence higher liking scores; (3) higher appropriateness in home use tests, including temporal appropriateness, hunger/thirst appropriateness; (4) prolonged product contact in home use test (HUT); and (5) increased sample contact in HUT. [Boutrolle et al.](#) recommend the laboratory test or CLT when the natural context is simpler, but they recommend the HUT when the consumption situation is more complex.

Two studies have used the meal context to study chicken-based meals. [García-Segovia, Harrington, and Seo \(2015\)](#) served an identical roasted chicken meal in a sensory testing booth, in a classroom with a plastic tray, in a home-style dining room at a table, and in an experimental restaurant with a gourmet setting. Participants rated the appearance of the food higher and were more willing to eat, but did not eat more, in the gourmet experimental restaurant. Also, the consumers ate more slowly, and perceived themselves to be less hungry, in the realistic settings versus the sensory testing booth.

[Hoek et al. \(2013\)](#) concluded that meal context is important in studies of products in extended home use testing. Products were consumed 20 times over 10 weeks. Meals containing meat substitutes (quorn, tofu) were equally liked, although product ratings were lower for meat substitutes than for chicken. Meals with meat substitutes were not boring over time, in contrast to the individual products. These results caution us to not make conclusions about meals from product components, even the main dish.

[Müller et al. \(2013\)](#) reported (as part of the HELENA–CSS study) on young (12- to 17-year-old) European students who ate lunch in cities across 10 different European countries. Students who did not eat lunch were excluded, and the others were grouped, based on self-report, into those (1) eating in the school restaurant or canteen ($n=231$), (2) bringing lunch from home or going home ($n=596$), and (3) eating in a local shop/fast food/

restaurant ($n=64$). More than half of the students depended on home for their midday meal. School meals had more potatoes and fewer sweets, home meals had more drinks and vegetables, while the food from shops, etc., had more sweets and the lowest amount of potatoes. A clear message from these data is the difficulty of generalizing across all teenage eating, even within Europe, where the patterns of eating lunch vary widely.

7.5 Contextual Effects Due to the Social Environment

A lot is written about recent dramatic changes in eating/dining, with some people claiming the breakdown of tradition and the breakdown of the family meal. On the other hand, others have argued that any changes in eating/dining are minor (Mestdag, 2005; at least for the period of the 1980–90s). Some of the most complete country data on eating patterns can be found in the study of eating patterns in the Nordic countries (Kjærnes, 2001), which included data from 1200 people (age 15+) in each of Norway, Sweden, Finland, and Denmark. The resulting detailed data (Holm, 2001) include tables of eating at home (2.5–2.7 meals per day on average), eating with family members (2.0–2.6 meals per day on average), and eating alone (1.2–1.4 meals per day average). Eating alone increases with age, with occupational inactivity, with single-person households, and decreases with education and urbanization. Detailed data are presented on different types of eating arrangements, their duration, and activities while eating at home. These data are valuable for those trying to describe Western eating in depth.

Holm et al. (2016) compared data from Denmark, Finland, Norway, and Sweden collected in 1997 and 2012. The results show minor “signs of individualization and informalization,” with adults reporting that they ate more often alone, and ate while using electronic devices. The results also reemphasized the stable pattern of primarily eating at home or at work.

Edwards and Hartwell (2004) collected food intake data (three consecutive 24-h periods) from hospital patients (ages 36–89) following surgery. Patients chose the condition in which they would receive their meals (at a group table, sitting by their bed, sitting in bed). Two conditions were individual and one condition was social. As shown in Table 1.3, the social condition led to a significantly higher food intake. The authors caution that self-selecting the eating situation might be a factor in these results.

Brindal, Wilson, Mohr, and Wittert (2011) noted the general finding that meal duration is associated with larger group size, and a body of research is available showing how food intake increases with increasing group size (Bell & Pliner, 2003; de Castro, 1990, 1994; de Castro and Brewer, 1992; Pliner, Bell, Hirsch, & Kinchla, 2006; Sommer & Steele, 1997; Stroebele & de Castro, 2004). However, Brindal et al. (2011) challenged this conclusion by reporting that diners eating alone can extend meal duration without

TABLE 1.3 Effects of Patient Eating Locations in a Hospital on Energy, Protein, Fat, and CHO Intake

	Meals at Table	Meals by Bed	Meals in Bed
Energy (kcal)	1632	1348	1363
Protein (g)	59.2	48.2	44.2
Fat (g)	60.6	52.8	63.5
CHO (g)	226.4	181.2	163.9

From Edwards, J. S. A., & Hartwell, H. J. (2004). A comparison of energy intake between eating positions in a NHS hospital—a pilot study. *Appetite*, 43(3), 323–325.

eating more. Although their data were based on observation of diners in a fast food environment, the authors argue that the relationships between eating alone, meal duration, and food intake are not specific to the fast food setting, and they call for greater understanding of the relationship of meal duration and intake.

7.6 Contextual Effects Based on Dining Location

We have already noted the studies conducted by King et al. at McCormick and Co., Inc., comparing different test situations, including different test variables. At about the same time, research was being carried out in the United Kingdom and the United States by colleagues who had access to student-run restaurants to study the effects of serving food in different environments. Restaurant food was consistently rated higher than student cafeteria food, even when the foods were identical. The results of the initial testing were reported by [Meiselman et al. \(2000\)](#), showing similar effects in both the United Kingdom and the United States in real meal situations. In both countries, the same food was prepared and served in different natural meal locations—the food did not vary, only the location. Restaurant food was rated higher than the more institutional food of the school cafeteria or canteen.

Following the previous tests, [Edwards et al. \(2003\)](#) studied the acceptability of centrally prepared foods in a number of different eating environments, probably the broadest range of eating environments ever studied in one study. The study food was centrally prepared to ensure that the food quality did not vary from location to location. The results, shown in [Table 1.4](#), reveal a variation of one scale point (6.6–7.6 on a 9-point scale) in acceptability ratings across locations.

[Cardello et al.’s \(1996\)](#) findings on consumer expectations, cited previously, can be used to understand these results. [Cardello et al. \(1996\)](#) broadened the study of meals from students to many institutional eating contexts,

TABLE 1.4 Hedonic Ratings of Centrally Prepared Foods When Eaten in a Number of Different Eating Environments (Letter Designations in Middle Column Represent Significant Differences Between Locations)

Location/Situation	Mean	Significant Differences ^a	N
Army camp	6.63	a	43
University staff refectory	6.64	a	36
Private boarding school	6.66	a	88
Freshers' Week Buffet	6.69	a	83
Private party	6.99	ab	77
Elderly residential home	7.05	ab	43
Student refectory	7.09	ab	33
Elderly day care center	7.09	ab	33
THR patrons	7.58	b	19
Four-star restaurant	7.63	b	32

^aMeans with different letters are significantly different at $P < .05$.
From Edwards, J. S. A., Meiselman, H. L., Edwards, A., & Leshner, L. (2003). The influence of eating location on the acceptability of identically prepared foods. *Food Quality & Preference*, 14, 647–652.

including schools, military, airline, and hospital compared with restaurant, home, and fast food/diner. The last three settings scored noticeably higher for how good the food was expected to be, demonstrating a clear anti-institutional bias.

There are examples of trying to simulate natural locations, without significant effects. For example, [Petit and Sieffermann \(2007\)](#) tried to study iced coffee in two simulations of natural conditions to save money and effort. Interestingly, they defined the essential conditions of natural testing for iced coffee: (1) warm environment to stimulate drinking cold beverages, (2) consumers not recruited and not told the purpose of the test, and (3) timing and social interaction were not controlled. They found no difference between the two laboratory tests, but did find differences between the simulations and the traditional laboratory context. The authors suggest that interactions between consumer testing groups, the actual locations used, and the testing conditions might have contributed to these results.

In a study of French nursing homes, [Divert et al. \(2015\)](#) varied how meals were served. They varied (1) the name of the main dish on the menu, (2) the size, variety, and portion of vegetables, (3) condiments or no condiments in the middle of the table, and (4) decorative objects on the table or music. The actual

food changes above (2, 3) increased nursing home members' meal enjoyment and the amount of food they consumed. The nonfood changes (1, 4) had no effect.

7.7 Contextual Effects Due to the Physical Environment

Bangcuyo et al. (2015) emphasized the potential importance of environmental effects and the threat of consumer boredom and lack of engagement in laboratory testing, which could lead to erroneous results. They describe testing in an immersive laboratory, simulating the sights and sounds of a coffee house, including a cinnamon roll aroma. The immersive environment had appropriate furniture for a coffee house. After coffee samples were served to the panelists in ceramic coffee mugs, the investigator left the room, and the recording of the test session began. The authors found that the immersive settings produced good discrimination among products and better prediction of future product liking. Panelists also reported being more engaged in the test.

Sobal and Wansink (2007) have reviewed the various physical dimensions of eating, kitchenscapes, tablescales, platescapes, and foodscapes. Most of their references deal with the amount of food consumed/portion sizes—much of this literature is aimed at understanding and intervening in the overconsumption that is occurring in many countries.

In van Kleef, Shimizu, and Wansink (2012), the authors compare their approach with the usual laboratory approach, noting that “Indeed, although eating often occurs in a social setting, nearly all portion size studies of adults are designed with participants serving themselves and then eating in isolation” (p. 68). Their study was conducted in “a sit-down family-style dinner,” and students did not pay for their meal. This was most likely not a natural meal situation. In this study, diners ate more from a large serving bowl than from a smaller serving bowl, felt more satiated, but did not like the product from the larger serving bowl significantly more.

In a study of popcorn consumption in a movie theater (Wansink & Park, 2001), consumers ate 53% more popcorn from a large container (240g) than from a smaller (120g) container. Consumers who rated the popcorn lower ate 61% more popcorn from a larger container than from a smaller container. Consumers who rated the popcorn higher ate 49% more from the larger container. The authors suggest that consumers had more difficulty monitoring intake from large containers.

Wansink et al. (2006) extended the portion size/container size studies to nutrition experts attending a social event. People were given a smaller (17 oz) or larger (34 oz) bowl and a smaller (2 oz) or larger (3 oz) ice cream scoop. The experts served themselves more in the larger bowl, and more with the larger ice cream scoop, and appeared unaware of their increased portions.

While a lot of research follows the theme of portion size and overeating, there are other points of view. For example, in a 2016 review article, Herman et al. (2016) argue that portion sizes have increased, but that there is no clear link to weight gain.

8. THE FUTURE

What does all of this research on context mean for the future of sensory and consumer research? Some time ago, [Meiselman \(1992\)](#) called for increasing the research in natural settings, a theme recently echoed by [Jaeger et al. \(2017\)](#). But, at the same time, since the early call for more natural testing, we have developed newer methods for data collection, which might improve our ability to conduct more ecologically valid contextual research in a laboratory testing. For example, immersive testing conditions might provide the critical components of the natural context and, hence, produce natural-like outcomes. In addition, online testing might enable the collection of context data with no interference from the experimenter, in real time and in real situations (at the movie, at dinner, at school, etc.). Another option for the future is the development and application of remote observational methods, which again would have no interference from the experimenter, and be in real time and real situations. What seems to be required is that various types of test alternatives are compared to natural testing and to laboratory testing to determine under what conditions these methods produce bias-free results.

In conclusion, it is our opinion that the future of contextual research, both lab based and natural, is promising. New methods and techniques will allow for a better understanding of how those elements that are external to the products we eat and use can affect our appreciation of them. In this way, it should be possible in the future to tailor our consumption and use environments to maximize our enjoyment and appreciation of the foods we eat and the products we use.

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Chapter 2

Evoked Contexts

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Chapter Outline

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1. STATE OF THE ART

Food choice is a complex process that depends on several interrelated variables that can be grouped into *characteristics of the person* who makes the choice, *characteristics of the product itself*, and *characteristics of the specific context* in which the choice is made (Köster, 2009). All these factors need to be considered when planning a consumer test, and different actions are needed to ensure relevant and valid responses. The characteristics of the *respondents* in a test are typically defined beforehand during the recruitment process through specific consumer criteria. It is also possible to define respondent characteristics in a consumer sample afterward if relevant information about the consumers is collected during the test (demographics, attitudes, eating habits, etc.). The characteristics of the tested *products* can be controlled by including chemical analysis and/or sensory descriptive analysis as a part of the test protocol. Finally, controlling the characteristics of the specific *context* in which the food choice is made or the product is consumed is often the most challenging issue. In this chapter possibilities for evoking specific contexts in consumer testing will be discussed. The literature of evoked context will be described and possibilities for how to evoke a specific context in the direction of the relevant eating situation for the specific product will be discussed.

The purpose of evoking a consumption context during consumer testing is to give the food product a more complete meaning and create more valid responses. According to Köster (2003), consumer testing in the absence of a context may imply a “situational fallacy” with the consequence that consumers

may be less involved in the selected products and thus will be unable to give an accurate hedonic rating. The reason for lack of involvement may be that while the sensory qualities of food allow for product recognition and identification, mental concepts such as product associations created through earlier eating situations/experiences are absent (Lyman, 1989). This suggests that by removing the product from the context in which it is normally consumed, a consumer may have less involvement with the product and accurate hedonic ratings may not be obtained.

The literature includes a relatively large amount of scientific papers that highlight the importance of allowing for contextual factors in consumer testing and consumer research. In some of these papers different approaches have been taken to create or evoke a certain consumption context, and the number of such papers has increased lately. One early example in which a context was evoked can be found in Bell, Meiselman, Pierson, and Reeve (1994). The authors studied the effects of adding an Italian theme to a restaurant by manipulating the physical environment by adding ethnic names and decorations. The findings from this study showed that perceived ethnicity was accomplished through such manipulations. Similarly, the effects of using different food names on sensory perception of food in restaurants was studied by Wansink, van Ittersum, and Painter (2005). Results from this study showed that the use of descriptive food names improved perceptions of the food in institutional settings. Approaches using labeling and the physical environment to manipulate food perception were extended by Petit and Sieffermann in 2007, who used visual, olfactory, and auditory cues to evoke a hot-weather context for evaluation of iced-coffee beverages. This study confirmed that hedonic liking and consumption of food are dependent on the situation and the surroundings of the test.

The concept of “evoked context” was systematically introduced into the literature in 2010 when Hein, Hamid, Jaeger, and Delahunty developed an approach for evoking a consumption context in a sensory laboratory by means of written scenarios. Written scenarios were defined as statements or brief texts meant to evoke a sense of presence in a real situation. The written scenario used in Hein et al. (2010) instructed consumers to imagine an occasion when a food or a beverage could be consumed and required them to think of that occasion during the test. Accordingly, the evoked context was the consumer’s response to the written scenario, and each consumer imagined his or her own personal occasion. The use of this type of evoked context, presented as a situation “when wanting something refreshing to drink” resulted in greater sample discrimination compared to the controlled laboratory setting. In addition, consumers using the evoked context found it easy to indicate their product liking/disliking, and felt that the liking information they provided was more accurate than consumers in the control setting.

In 2012, Hein, Hamid, Jaeger, and Delahunty published a follow-up study on the effects of evoked consumption context, in which hedonic ratings of two different fruit beverages were studied (four apple juices and four black currant juices). Written scenarios in this case were used to evoke the following three

consumption contexts for drinking a fruit beverage: (1) while eating breakfast, (2) while watching a movie, and (3) while having something refreshing to drink. The authors had in this case predefined the three different contexts during pilot work, and the written scenario was presented on a screen, read aloud twice, and then included at the top of each page on which hedonic ratings were recorded. A greater effect of evoked consumption contexts on hedonic response was observed for the black currant juice compared to the apple juice, but ranking order of the juice samples was similar across contexts. This study demonstrated that hedonic responses to products are influenced by the product type and the type of evoked consumption context.

In 2013, Sester, Deroy, Sutan, Galia, Desmarchelier, Valentin, and Dacremont investigated the impact of ambience on drink choices. They used physical means (i.e., furniture, colors, visual and music stimuli) to evoke different ambiances in two bar-like environments. The results showed that these elements were sufficient to have an influence on declarative drink choices, and the authors concluded that the immersive approach might be a good tool for exploring the integrated influence of contextual variables on food and drink choices. Giménez, Gagliardi, and Ares (2015) followed up along the same lines with a study on the effects of evoked context on consumers' rejection of products seen in the light of shelf life estimation. The contexts in this paper were evoked using written scenarios. The authors compared consumers' rejection of consumption of orange juice samples with different storage times, at home and in a supermarket context. Results showed that estimated shelf lives based on consumers' rejection of *purchasing* (in a supermarket) were shorter than those estimated considering consumers' rejection of *consuming* (at home). Moreover, Giménez et al. (2015) included a second study, also using written scenarios, in which they compared consumers' rejection of consumption of *dulce de leche* of brands of different familiarities and samples with different plastic flavor intensities. Findings from this second study showed that consumers were harsher when considering whether to repeat purchase of a new brand compared to their usual brand.

De Andrade, Nalério, Giongo, Barcellos, Ares, and Deliza (2016) evaluated the influence of evoked consumption contexts on consumers' intention to purchase lamb meat cuts using rating-based conjoint analysis. The variables in the conjoint analysis were type of cut, presentation, seasoning, and price, and the participants were asked to evaluate their intention to purchase lamb meat for two different contexts, either for "a weekend lunch context" or for "a weekday dinner context." The intention to purchase scores were significantly affected by the evoked context. For example, consumers were more willing to purchase lamb meat for a celebratory weekend compared to a weekday dinner. Moreover, two segments were found in the study, which gave different relative importance to the variables included in the conjoint task, and this was dependent on the type of context. Accordingly, the results suggest that evoked consumption context is also an interesting methodological approach to increase the validity in a conjoint study.

In 2014, the investigation of how evoked context influences consumer responses was extended beyond hedonic responses and sensory characterization to the inclusion of emotional product associations (Piqueras-Fiszman & Jaeger, 2014a, 2014b, 2014c). These studies explored how evoked consumption contexts (presented in written format) can affect associative emotional responses to products. Results showed that positive emotions were more frequently selected in appropriate consumption contexts, while negative emotions were more frequently selected in the less-appropriate contexts. Accordingly, the studies include discussions on how specific means of presenting food stimuli and the chosen consumption contexts (evoked by written and pictorial vs. written only) influence the perceived appropriateness of the products. Further, Dorado, Chaya, Tarrega, and Hort (2016) followed up the topic of evoked context versus emotional response through a study aimed at evaluating the effects of using a freely elicited scenario on the emotional response profile, as well as liking and familiarity of commercial beers. Results of this study showed that certain emotions were more discriminating in the scenario condition compared to no scenario, indicating that some emotions may be more relevant in particular contexts.

Finally, in 2017 a comprehensive study was published discussing the influence of evoked context on hedonic product discrimination and sensory characterization (Jaeger et al., 2017). The paper compares the use of evoked contexts versus no evoked context in 12 studies involving 1727 consumers, including consumers' hedonic responses and sensory product characterizations using check-all-that-apply questions. Jaeger et al. (2017) discuss several aspects regarding possible influences of evoked context on hedonic responses and sensory product characterization. Overall, the results showed no consistent trend regarding the influence of evoked context on hedonic responses. For consumers, evoked context may provide a frame of reference for their sample evaluations, but it cannot be assumed that means and sample discriminations are improved. These results mirror the results from the studies discussed in this chapter, namely that results of the evoked context are not conclusive; some studies show an effect and others do not.

Summing up the state of the art of evoked context, we can see a lack of consistency in the results. The reasons may be diverse. First, possible effects are a consequence of how the context is evoked, and there may be both smaller and larger differences between test protocols in the reported studies. For example, some studies have used predefined written scenarios, some personalized scenarios, and in some studies pictures are included. Next, the appropriateness of the context is a critical factor that needs attention. The type of product is another reason for variation in effects of evoked context, an issue that will be further discussed in the next section. Moreover, the frequency of product consumption may be a possible factor explaining inconsistency in results. With infrequently consumed products, consumers may find it difficult to recognize the evoked context.

It will be important to do further research to establish parameters for when evoked context will or will not influence consumers' product evaluations. Moreover, the final important question regarding effects of evoked context is the relevance for consumers' real food choice and food perception. No study has so far evaluated if scores under evoked context have higher predictive ability or are more similar to real-life behavior than scores given without an evoked context. Such studies will be welcomed in the future sensory literature.

1.1 Important Considerations When Evoking a Context

When planning a consumer test, it is important to remember that the consumers always have a set of expectations regarding the food that they buy, choose, eat, or get served. Such expectations are results of earlier experiences with the current food plus the additional product information the consumers may have in the actual situation. For example, if a person usually drinks many different types of apple juices and nectars in many different situations (refreshment, lunch, dinner, evening), he/she will have a set of sensory expectations about apple juices that are relatively broad. On the other hand, if a person always drinks high-quality apple juices (pure juices) in specific situations (i.e., for refreshment), he/she will have a set of sensory expectations that are relatively narrow. It is possible to partly control for differences in expectations during the recruitment process, but there will still exist large variations that may influence the responses in a test. Instructions given to the respondents before and during a consumer test are therefore highly important, and these may support consumers' initial expectations or move the expectations in a certain direction.

In a consumer test, the physical environment is predefined and set when the consumers arrive at the test location. However, the given introduction about the test to the consumers is important and should in most situations include a welcome, neutral information about the principles of the test, and an explanation of the procedure, i.e., how many samples, number of sessions, duration of the test, etc. Regardless of the type of consumer test, it is important to carefully plan what to say (and what not to say) when welcoming consumers to the test, as well as the instructions given during the test. All types of given information will influence consumers' expectations for the products and possibly the responses given in the test.

In addition to a need for general instructions to consumers when they arrive for a test, it is possible to evoke a context (to adjust the expectations). Two main approaches for evoking a context exist:

1. the use of a written scenario to evoke a sense of presence in a real situation, sometimes including pictures of the products;
2. the use of physical means (furniture, decoration, music, etc.) that deliver an immersive consumption experience.

The written scenario could be predefined by the project leader, i.e., the evoked context is given, or the consumers could be asked to imagine a relevant occasion when the food or the beverage is consumed, i.e., a personalized evoked context. The best practices about how to evoke a context are not yet established, and we do not know the effects of asking consumers to describe the context they imagine versus giving them a written scenario, or the effects of showing them pictures of the products and/or the eating context. For example, [Jaeger et al. \(2017\)](#) found that a personalized evoked context resulted in smaller sample discrimination than a predefined context.

When using a predefined written scenario it is important to carefully design the text, and to pretest the messages with persons who are representative of the consumer sample regarding use of the product, age, education, etc. Pictures may also be added as a support to the written scenario, and this can represent a strong medium and give consumers associations followed by certain expectations. It is therefore important to also carefully discuss the choice of pictures and to test these out with representative persons.

The use of physical means or simulated environments is an interesting approach for evoking a context for which fewer examples are shown in the literature. Such mediums may also have strong and sometimes unpredicted effects, i.e., the use of colors and/or music in a consumer test may give the consumers certain associations and also sometimes emotional feelings. Carefully pretesting such environmental factors should therefore be included by pilot testing with a representative consumer sample.

As pointed out earlier, one possible reason for lack of consistency in the literature on evoked context is that effects are dependent on the type of product. The influence of consumption context on food perception varies from product to product, and constructing appropriate tailor-made testing conditions is therefore critical for securing valid consumer responses. For example, wine is a product for which sensory perception is strongly influenced by consumers' expectations ([Hersleth, Mevik, Næs, & Guinard, 2003](#)). Evoking a context in a consumer test of wine is therefore highly relevant and may include written scenarios describing physical and social situations for drinking wine. In contrast, an example of a product that may be less influenced by expectations is cheese. This is an everyday product that is frequently used for many different occasions, and [Hersleth, Ueland, Allain, and Næs \(2005\)](#) found that acceptance scores for such a product were relatively stable across different eating situations. Therefore, evoking a context in a consumer test on cheeses may not be essential for the test validity. Moreover, as already pointed out, the need for evoking a consumption context and/or meal context will vary as a function of appropriateness. In some cases, the collected responses will be robust across different contexts/meals (appropriateness is less important), while in other cases the appropriateness of the eating situation is essential for achieving representative results ([Schutz & Martens, 2001](#)).

2. CASE STUDY ON DRY-CURED HAM

Hersleth, Monteleone, Segtnan, and Næs published in 2015 a study including evoked consumption contexts for choice of and acceptance of dry-cured ham. The main objective in the research was to explore how two different evoked meal contexts affected consumer responses to a set of products in relation to intrinsic and extrinsic cues. The contexts were two common ways of serving dry-cured ham in Norway (a traditional meal and a novel meal), and the effects of the evoked meals were studied for both sensory attributes and various extrinsic product attributes (origin, aging time, and price). Accordingly, two common approaches to consumer testing of food were applied, namely acceptance testing—where consumers’ sensory perception of product attributes is the main focus—and probability of buying—where consumers’ valuation of extrinsic product attributes (cues) is the main interest.

Six types of dry-cured ham were selected for the study: two Norwegian, two Italian, and two Spanish hams. Descriptive profiling of the hams was included to reveal significant differences between the hams. Two Norwegian meal contexts, appropriate for the consumption of dry-cured ham, were introduced to the consumers. The first was a traditional meal consisting of dry-cured ham and scrambled eggs (meal 1), and the second was more novel in the Norwegian market, and comprised several small dishes, i.e., “finger food” or “tapas” (meal 2).

Altogether, 120 consumers participated in the test. The consumers were recruited based on the following criteria: that they like dry-cured ham, that they buy and eat dry-cured ham regularly, and that they had eaten Norwegian ham and either Italian or Spanish ham during the previous 6 months. The consumer test was run as a central location test during 2 days on Nofima’s premises. The sample was split into two groups of consumers (group 1 and group 2), and the test included a total of four sessions per group. All samples were presented according to a cyclic design to avoid order and carryover effects.

The intrinsic rating was undertaken under blinded conditions and the six samples of dry-cured ham were presented and served twice, i.e., group 1 started with the context of meal 1 (session 1) and continued with the context of meal 2 (session 2). Group 2 had the opposite meal order. The consumers were served the samples one by one (0.6-mm-thick half-slice of ham), with plain crackers and water to rinse the mouth during the test. The samples were accompanied by written scenarios, including pictures, intended to evoke the two different meal contexts. The pictures representing the two different meals are shown in Fig. 2.1 (meal 1 = traditional meal) and Fig. 2.2 (meal 2 = novel meal). The pictures for the test were chosen by the research group. It was decided that one picture was enough to represent the traditional meal (a standard type of meal), while two pictures were needed to represent the novel meal (more variation in type of meal). The following instructions were given to the consumers during the



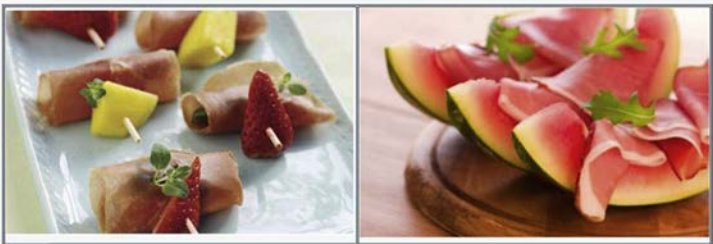
Please evaluate sample 493

Imagine a situation where you eat a meal with dry cured ham and scrambled eggs.

How much do you like or dislike this dry cured ham?



FIGURE 2.1 Picture and written scenario representing the traditional meal (meal 1).



Please evaluate sample 894

Imagine a situation where you eat dry cured ham in a meal with several small dishes i.e. "finger food" or "tapas".

How much do you like or dislike this dry cured ham?



FIGURE 2.2 Picture and written scenario representing the novel meal (meal 2).

blind tasting (intrinsic rating): “We will serve you six different samples of dry-cured ham. Imagine a situation where you eat a meal with dry-cured ham and scrambled eggs” (Fig. 2.1 was shown on the screen). Alternatively, consumers were instructed to “Imagine a situation where you eat dry-cured ham in a meal



Imagine that you are in a shop and that you are going to buy a package of dry cured ham to a meal with dry cured hams and scrambled eggs.

Look at the image, and rate your probability of buying this package of dry cured ham.



FIGURE 2.3 Example of picture and written scenario presented for extrinsic rating purpose.

with several small dishes, i.e., “finger food” or “tapas” (Fig. 2.2 was shown on the screen). The consumers were asked “How much do you like or dislike this dry-cured ham?” The rating scale shown in Fig. 2.1 and Fig. 2.2 was a modified 9-point hedonic scale (Peryam & Pilgrim, 1957).

2.1 Extrinsic Rating

During extrinsic rating, for which the products were presented in packaged form, it was important that the consumers focused primarily on the external attributes. Accordingly, the samples inside all six packages consisted of the same type of neutral/typical dry-cured ham. The information provided in connection with rating of probability of buying was origin of production, aging time, and price per 100 g. The presented prices corresponded to the real prices of the products in the Norwegian market. The information was given on white labels. The origin was indicated by flags, aging time in number of months, and prices in NOK per 100 g (an example is shown in Fig. 2.3). Commercial branding of products was not included.

During the extrinsic rating test, six different packages of dry-cured ham with information on origin, aging time, and price were presented on the screen twice (one by one), i.e., group 1 started with purchase probability related to meal 1 (session 3) and followed with purchase probability for meal 2 (session 4). Group 2 had the opposite meal order. An example of a picture presented to the consumers is shown in Fig. 2.3 (Norwegian dry-cured ham, 4 months, NOK 45 per 100 g). When the pictures were presented to the consumers, they were instructed as follows for the traditional meal: “Imagine that you are in a shop and that you are going to buy a package of dry-cured ham for a meal with dry-cured hams and scrambled eggs. Look at the image and rate your probability of buying this package of dry-cured ham.” Alternatively, for the novel meal: the

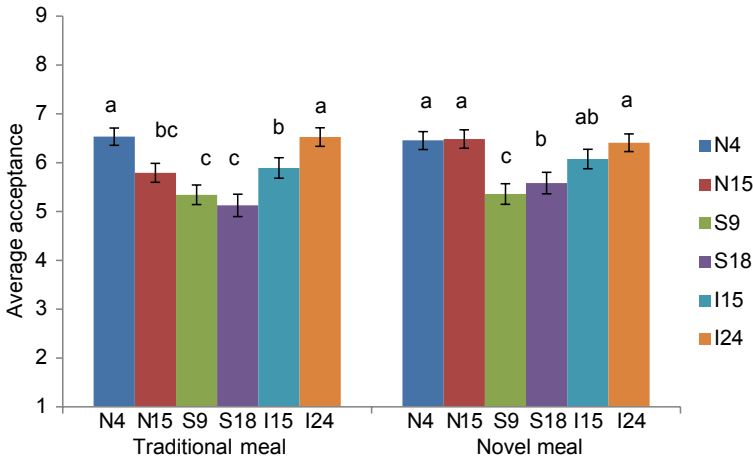


FIGURE 2.4 Average acceptance values for the six samples of dry-cured ham including standard error of the mean. Different letters indicate significant differences at the 5% level.

participants were instructed to “*Imagine that you are in a shop and that you are going to buy a package of dry-cured ham for a meal composed of several small dishes, i.e., “finger food” or “tapas.” Look at the image and rate your probability of buying this package of dry-cured ham.*” Note that the pictures of the two meal contexts were not shown in connection with extrinsic rating, so evocation was in this case based on the written text alone. However, it is important to note that all consumers performed blinded rating, including both pictures and text, before informed rating. The extrinsic rating was based on a 9-point scale from 1 (=no probability) to 9 (=very high probability).

ANOVA was performed on the acceptance data and the probability-of-buying data for the traditional meal and the novel meal (two-way model with products and consumers considered random). Moreover, separate ANOVA models were prepared for the effects of meal on the acceptance data and probability-of-buying data (GLM model including interaction effects with product, meal, and consumers as factors, consumers and interactions considered random). The level of significance in the ANOVA models was $P=.05$ and Tukey HSD was used as a post hoc test. A possible effect of meal order on rating was checked and disconfirmed.

The average results for intrinsic rating of the hams in different evoked meal contexts are shown in Fig. 2.4. The figure shows that the acceptance rating patterns of the six products were similar for both meals, but that the products were slightly more differentiated in the traditional meal context than in the novel meal context, especially in the case of the Norwegian and Italian hams. The consumers were probably more familiar with the traditional meal than with the novel meal, as a consequence of a higher meal frequency and the fact that the traditional meal has been part of Norwegian food culture for longer than the

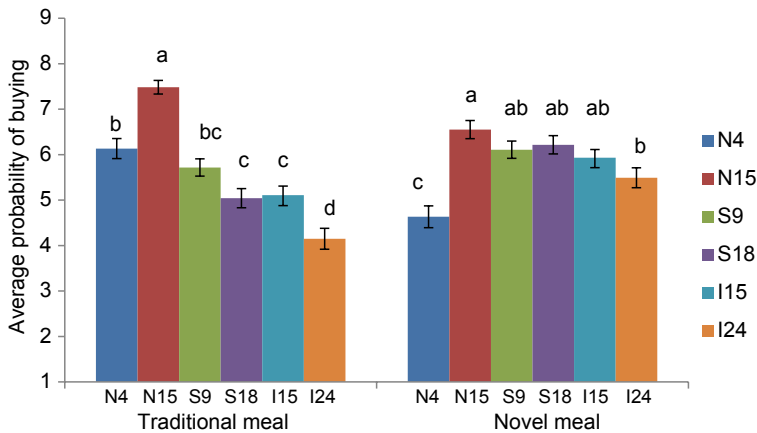


FIGURE 2.5 Average probability of buying for the six packages of dry-cured ham including standard error of the mean. Different letters indicate significant differences at the 5% level.

novel meal. A relatively high mean age of the consumer sample (44.8 years) was a further explanatory factor. The results of the ANOVA on the impact of the evoked meal on intrinsic attributes showed a P value of 0.05. Moreover, the product–meal interaction effect was significant ($P=.03$). This shows that the intrinsic rating was dependent on the meal, and that evoking a meal context for this type of product is relevant when collecting hedonic consumer responses.

The average results for extrinsic rating in the different evoked contexts are shown in Fig. 2.5. When rating packages of ham with regard to probability of buying based on extrinsic attributes, the consumers scored N15 highest in both evoked meal scenarios. N4 scored second highest in the traditional meal scenario. All samples except N4 scored just under N15 in the novel meal scenario (only I24 scored significantly lower than N15). Moreover, in the traditional meal context, the consumers indicated a significantly lower probability of buying for product I24 compared to all other samples, and a significantly lower probability of buying S18 and I15 compared to N4 and N15.

Fig. 2.5 shows that sample N15 received a significantly higher score than the other samples in the traditional meal scenario, and this strong pattern was not equally observable in the novel meal context. Moreover, a higher discrimination between samples in relation to the traditional meal than the novel meal was observed. This supports the trend observed in relation to intrinsic rating, namely that the consumers were more discriminating in the case of familiar meals than in the case of novel meals. Accordingly, evoking a meal context by written text and pictures is more effective with respect to a familiar meal than a novel meal. The possible underlying reasons for the different patterns observed for the traditional meal and the novel meal may be the appropriateness of the different hams for each type of meal. For the traditional Norwegian meal, consumers seemed to prefer the hams labeled as being Norwegian as opposed to the others, while for

the tapas meal the hams from Spain and Italy were considered more appropriate and the probability of buying was therefore higher.

The results of the ANOVA on the impact of the evoked meal showed a significant effect of the meal ($P = .01$). Moreover, the product–meal interaction was also significant ($P < .001$). This shows that extrinsic rating was strongly dependent on the meal, and that evoking a meal context for this type of product is relevant in consumer testing.

In this study we included both intrinsic and extrinsic attributes, and the argument for such an approach is the pronounced influence of consumer expectations on product choice and perception. When consumers choose a product in the shop, they do so based on previous experience, e.g., brand associations, price, etc. These cues are not necessarily reflected in the sensory attributes they perceive when they eat the product as part of a subsequent meal. A difference between sensory-based and/or hedonic-based expectations and subsequent actual perception may induce assimilations in both positive and negative directions (Deliza & MacFie, 1996; Hersleth, Lengard, Verbeke, Guerrero, & Næs, 2011). For example, if a person (consumer) plans to serve a traditional Norwegian meal, Fig. 2.5 suggests that he/she will prefer to buy N4, N15, and/or S9 rather than S18, I15, and I24. If he/she had eaten these products in an uninformed condition, N15 and S9 would be perceived as being worse than expected, and N4 would be perceived as better than expected (Fig. 2.5).

In summary, this case study demonstrated an effect of evoked meal context on intrinsic and extrinsic rating of dry-cured ham. This effect was most evident in the case of extrinsic rating, i.e., for the probability of buying, and when evoking a familiar meal. Moreover, this study confirms the importance of meeting both consumers' hedonic and sensory product expectations and that this may be critical for market success at a time when food habits and meal composition are changing. Accordingly, it is important to further improve and develop existing consumer-testing procedures, and to incorporate instruments allowing for the possible effects of meal and consumption contexts.

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Chapter 3

Immersive Techniques and Virtual Reality

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1. INTRODUCTION

The role of context in product experience no longer needs to be demonstrated, as the experience of food or scented products has been shown to be affected by visual perception and the context in which it occurs. For example, a single molecule, such as isovaleric acid, can be associated with the smell of cheese and pleasant experiences, or it can be associated with the smell of dirty feet and unpleasant experiences, for example, in sports club cloakrooms. Moreover, one does not always like the same food or the same fragrance over time or in different situations. Consumer behavior, or the choice of eating or drinking, or of wearing a certain perfume, is therefore influenced by many interacting personal and situational factors.

The literature on the influence of context is rich; many authors have already shown the effects of changes in external factors on food choices and behaviors. For instance, different locations induce different food choices and preferences (Edwards, Meiselman, Edwards, & Leshner, 2003; Hersleth, Ueland, Allain, & Næs, 2005; King, Weber, Meiselman, & Lv, 2004),

lighting has an impact on pleasantness (Quartier, Vanrie, & Van Cleempoel, 2014), and music intensity in nightclubs increases soft drink consumption (McCarron & Tierney, 1989) and changes food intake (Stroebele & De Castro, 2006). Other authors have studied the effects of changing the size, weight, and color of food containers (e.g., Libotte, Siegrist, & Bucher, 2014; Piqueras-Fiszman, Alcaide, Roura, & Spence, 2012; Piqueras-Fiszman, Harrar, Alcaide, & Spence, 2011; Wansink, Van Ittersum, & Painter, 2006); of changing various elements of packaging on food choices, intake, and preferences (Guéguen & Jacob, 2012; Gutjar et al., 2015; Piqueras-Fiszman & Spence, 2015; Piqueras-Fiszman & Jaeger, 2014; Sáenz-Navajas, Ballester, Peyron, & Valentin, 2014); and of changing elements of odor on emotional responses (Porcherot, Delplanque, Gaudreau, & Cayeux, 2013; Porcherot et al., 2012). However, all of these studies dissected and reconstructed the impact of isolated single context effects independently, rather than studying them in a more integrated manner (Köster, 2009). These experimental conditions are still far from re-creating a real-life situation and replicating the complexity of real-world experiences. However, for research on emotions in particular, it is crucial to re-create test situations as they would typically occur in real life to generate continuous and recursive evaluations of events that are necessary to generate emotional responses (Ellsworth & Scherer, 2003). Moreover, the replication of everyday life environments in laboratory settings could improve the ecological validity of the results (Spooner & Pachana, 2006).

Some studies have tried novel approaches to study the influence of context by integrating real-life situations with laboratory settings. In these studies, situations of consumption were first evoked and participants were instructed to imagine the situations from brief text descriptions (Jaeger & Meiselman, 2004), pictures (Hersleth, Monteleone, Segtnan, & Naes, 2015), audio recordings (Köster, 2003), or written scenarios (Hein, Hamid, Jaeger, & Delahunty, 2010, 2012). Immersive approaches were then implemented and consisted of re-creating a full experience in the laboratory setting. Sensory laboratory environments were set to evoke a natural consumption situation and were re-created in terms of visual, auditory, and olfactory cues; lighting; and room temperature. For example, different authors re-created coffee shop environments either by using physical elements that re-create a coffee shop atmosphere (Petit & Sieffermann, 2007) or by projecting a coffee shop environment on large video screens (Bangcuyo et al., 2015). The immersion retains the idea of a controlled setup from laboratory settings, but builds on the manipulation of contextual variables and the observation of their possible integrative effects on behavior.

An even more recent immersive technique appeared to become a promising tool for studying consumer behavior: immersive virtual reality (iVR). iVR is a computer simulation that immerses people into almost real environments. Participants wear glasses for full immersion, allowing them to see and interact

with the environments provided in three dimensions (3D). This new immersive technology has the advantage of being able to re-create the complexity of the real world, at the same time allowing experimenters to constrain experimental parameters (Ischer et al., 2014). Another key advantage of this technology is an increase in the sense of presence and the elicitation of vivid emotional experiences by involving all senses (Dinh, Walker, Hodges, Chang, & Kobayashi, 1999; Scholz & Smith, 2016).

The objective of this chapter is to present different immersive approaches used for re-creating a full experience in laboratory settings, from re-created environments with physical elements, to environments projected on the screen, to 3D immersions with iVR. This chapter in particular details the experiment that the authors conducted for the study of emotions elicited by scents in iVR. The different immersive approaches are compared in terms of level of immersion, possible bias, and the validity of such approaches to predict consumer behavior and preference.

2. DIFFERENT IMMERSIVE TECHNIQUES

2.1 Re-created Environments With Physical Elements

The principle of re-created environments is to evoke a situation of natural consumption or use in a sensory laboratory by using different furniture and devices for a multisensory experience.

As a first attempt, Petit and Sieffermann (2007) compared four test conditions to study the effects of the drinking environment on consumer consumption and liking of iced coffee: a classic laboratory test under controlled conditions without any reference to a drinking situation, two tests performed outside the laboratory in natural drinking situations, and a situational laboratory test modified to evoke a “hot” ambience by using selective elements such as desert pictures, yellow curtains, and spotlights. The results indicated that the situational laboratory test was no different from the classic laboratory test. This approach was, however, advocated in consideration of its optimized cost, organization, and administration in comparison with tests conducted in natural environments.

Sester et al. (2013) worked on a higher level of immersion in bar-like environments and compared two ambiances by changing the color of the furniture (wooden or blue tables) and the music and videos, which were projected on a wall. Thanks to these more drastic changes in bar ambience, the authors showed that differences in the overall warmth led to different drink choices. For instance, participants more frequently selected warm beverages when the video clip presented icebergs. The authors concluded that this immersive approach is valuable for studying the effects of manipulating contextual variables in an integrated way.

Kim, Lee, and Kim (2016) compared an evocative condition with a simulated café condition. In the evocative condition, subjects were instructed to read evocative phrases and to imagine the situation. In the simulated café condition, the room looked like a common café with brown tablecloths and various types of furniture as might be found in cafés. The results indicated that simulating the physical environment was more effective than imagining a situation.

The different approaches appeared to be interesting and effective in studying the effects of context when the re-created environment came close enough to natural situations.

2.2 Projection of Environments on a Screen

In the following studies, a natural consumption situation was re-created with video projections in laboratory settings. As a first attempt, the authors of the studies used video screens to investigate consumer behavior at the point of purchase and to study the influence of packaging, shelf placement, pricing, and advertising (Daugherty, Li, & Biocca, 2005). In the same vein, Domina, Lee, and MacGillivray (2012) studied factors affecting consumer intention to shop in a virtual world and showed that the perceived enjoyment of consumers influenced their shopping intentions.

More recently, Bangcuayo et al. (2015) re-created a virtual coffeehouse by projecting a 20-min video onto high-definition LCD screens. The video evoked a natural situation of the multisensory experience by depicting the sights and sounds usually experienced in a coffeehouse. Compared with a classical laboratory test under controlled conditions, this study showed the influence of an immersive approach, with significant differences in the order of preference between the two settings. Interestingly, more discrimination occurred in the virtual coffeehouse. More engagement, as measured by the Engagement Questionnaire (O'Brien & Toms, 2010; Witmer & Singer, 1998), was also found, which may contribute to more reliable prediction of coffee liking in natural conditions. A possible higher predictive value would need to be validated by comparing this immersive approach with tests conducted in natural situations.

2.3 Creation of Immersive Virtual Environments

iVR is a computer simulation that immerses people into almost real environments with the perception of being physically present in a nonphysical world. With the development of new technologies, virtual reality offers many new experiences and possibilities, such as playing and enjoying events (interactive gaming and entertainment, immersive movies and live concerts, and other events), learning (training and demonstrations, 3D design, and art), and communicating (sharing personal moments and social interactions). Virtual reality glasses (i.e., Oculus VR) can produce a visceral feeling of being in a

simulated world, a form of spatial immersion called presence. The advantage of such virtual experiences is that they activate multiple sensory pathways when all senses work together, which may elicit more emotions and increase consumer engagement (Dinh et al., 1999; Scholz & Smith, 2016; Witmer & Singer, 1998).

Although iVR was developed mainly for gaming purposes, as well as for therapy (to reduce pain and anxiety in burn victims, Morris, Louw, & Grimmer-Somers, 2009; to help restore memory deficits in people with acquired brain injury, Yip & Man, 2013; and to reduce compulsive eating-related disorders, Cesa et al., 2013; Perpinã & Roncero, 2016; Gutiérrez-Maldonado, Wiederhold, & Riva, 2016), it seemed that this new technology could offer many possibilities for research on consumer behavior. For example, Ahn, Bailenson, and Park (2014) showed that watching a video depiction of the tree-cutting process versus reading a print description encouraged paper conservation. This higher engagement by consumers was confirmed by Serrano, Botella, Baños, and Alcañiz (2013) for a virtual reality environment related to ceramic tiles. Users could choose between different kinds of products and test them out. These experiences were efficient at inducing relaxation and a high sense of presence among the participants.

Other authors (Pantano & Servidio, 2012) studied the benefits of virtual reality in retail stores and observed that consumers were more attracted to these stores, and more attracted to use them, than they were to traditional retail stores. Finally, Van Herpen, Van den Broek, Van Trijp, and Yu (2016) found that, compared with a pictorial (2D) store, a virtual store elicits behavior that is more similar to behavior in a physical store in terms of product selection and amount of money spent. However, the virtual reality condition did not completely reproduce behavior in natural conditions in that participants in virtual reality stores were tempted to buy more products, spend more money, buy more national brands, or respond more strongly to price promotions than they were in physical stores.

In consideration of the idea that all the senses could work together to create memorable experiences and increase consumer engagement, it seemed necessary to add taste and olfactory dimensions to iVR.

3. INTRODUCTION OF THE OLFACTIVE MODALITY INTO iVR

Because olfaction is more complex to implement and control, its use in iVR environments remains more the exception than the rule (Bordegoni & Carulli, 2016; Carulli, Bordegoni, & Cugini, 2016; Nakamoto & Hai Pham Dinh, 2007; Nakamoto et al., 2008; Ramic-Brkic & Chalmers, 2010; Richard, Tijou, Richard, & Ferrier, 2006; Tortell et al., 2007). The introduction of olfactory and taste modalities into iVR is an important challenge, especially when the purpose is to compare the perception of different odorants or food products in different virtual environments.

An attempt at virtual taste experiences was made by [Ranasinghe, Lee, Suthokumar, and Do \(2016\)](#) by using weak and controlled electrical pulses on the tip of the tongue, which simulate primary taste sensations such as salty, sour, and bitter in order to modify existing taste sensations. This experiment was, however, not related to real taste introduced into a virtual environment. [Narumi, Kajinami, Nishizaka, Tanikawa, and Hirose \(2011\)](#) worked on the perception of a cookie while overlaying visual and olfactory information onto a real cookie with an augmented reality marker pattern. This system showed changes in perceived taste based on the effect of the cross-modal interaction of vision, olfaction, and taste.

The introduction of olfaction into iVR was to be a challenge to overcome. These studies, which introduced olfaction into iVR, did not work precisely on the delivery system. The objective of the present study was therefore to create an advanced odor delivery system in a 3D, immersive, and fully interactive visualization environment for the delivery of various complex and reproducible scents at a precise time and space and without contamination of the environment. A custom-made olfactometer with a constant and low airflow rate of 1 L/min was used for this purpose. Odors were delivered to the participants with a light nasal cannula connected to the olfactometer. An air extraction system was used to avoid odor contamination. Participants were placed in a room where 3D, immersive, and interactive worlds were projected. A custom-made system of nose position tracking in 3D was designed to deliver odors when the nose of the participant entered the olfactory volume defined by the user. Participants were instructed to move in the virtual environment with a gaming joystick to smell the odor of different objects that were placed in these environments and were visible to the participants. Odors were delivered when the nose of the participant was close enough to the object. The precision of the olfactory delivery was measured for 15 different odorants with a photoionization detector (200B miniPID, Aurora Scientific, Inc.), which revealed a short latency of 400 ms after the triggering command. The lack of contamination between odors was validated thanks to the recovery of baseline levels observed after 2 s. The main features of this device (fully described in [Ischer et al., 2014](#)) were the lack of cross-contamination between odorants with a rapid delivery time, the ease of use and control, and the possibility of synchronizing the delivery of the odorants with the objects in the environments while taking into account the subject's breathing pattern.

The efficiency of the odor delivery system being validated, it was possible to investigate the extent to which such virtual experimental settings could be applied to the study of emotions elicited by scents. Odors were delivered in three different immersive worlds (kitchen, bathroom, tramway) to study the influence of iVR on emotional responses to scents. In addition, different levels of immersion were compared to explore the benefits of the virtual reality system: a condition without any immersion, immersion with computer screens, and full immersion in a virtual reality laboratory.

3.1 Method

A within-subject experimental design was used that included three different experimental environments (Fig. 3.1) and different levels of immersion (1D in sensory booths without immersion, 2D in sensory booths with the interactive virtual worlds shown on a computer screen, and 3D in an iVR system with the same environments as those used for 2D immersion (Fig. 3.2)). A total of 30 subjects participated in three sessions of 30 min each (one session per week). One session corresponded to one level of immersion, with experiments conducted in three virtual worlds and with the delivery of 21 odorants. The three environments were presented to the participants in the same session, following a balanced design and order.

In the first condition (1D, no immersion), the session was conducted in sensory booths and participants smelled the odors by having the corresponding pictures of objects presented on the computer screen (i.e., picture of an apple when an apple odor was delivered). In the second condition (2D, immersion in



FIGURE 3.1 Pictures of the three 3D environments (kitchen, bathroom and tramway).

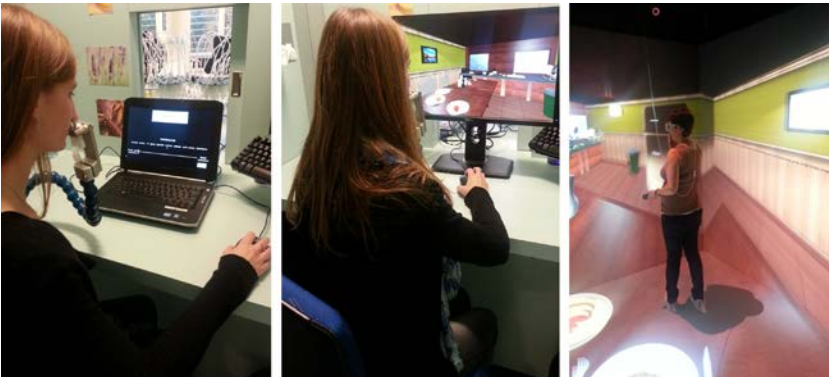


FIGURE 3.2 Pictures of participants completing the test in the three conditions (1D, 2D, 3D).

sensory booths), the session was conducted in sensory booths and the interactive virtual worlds were shown on a large computer screen. The third condition (3D, full immersion) corresponded to full immersion with the 3D settings, in which interactive virtual worlds were projected onto the virtual laboratory walls and the subjects wore glasses for 3D vision. Odors were delivered with the same olfactometer in these three conditions.

In the 2D and 3D conditions, subjects were instructed to move in the kitchen and bathroom environments to smell the odors of different objects in these worlds. Participants could smell the odor only if they were close enough to the objects. Participants were seated on a chair in the tramway condition as if they were sitting in a tramway. The odors were delivered when avatars passed by the participants from back to front. Every odor was delivered for 6 s in each condition. Of the 21 odors delivered each session, two were delivered in the three virtual worlds and associated with different objects. Isovaleric acid was associated with cheese in the kitchen, dirty laundry in the bathroom, and a dirty-looking avatar in the tramway. Tiare flower was associated with tea in the kitchen, clean laundry in the bathroom, and a good-looking avatar in the tramway. Some odors were specifically delivered in the kitchen environment (chocolate cake, trash bin, and two odors of apple), others in the bathroom environment (soap, sponge, and two candles), and others in the tramway (perspiration, fine fragrance, and two deodorants).

Emotional responses were measured by using psychophysiology recordings (heart rate, respiration, and electrodermal activity) with the Biopac System (Santa Barbara, CA), and verbalization of the affective feelings was obtained with the ScentMove questionnaire (Ferdenzi et al., 2013; Porcherot, Delplanque, Ferdenzi, Gaudreau, & Cayeux, 2016). The ScentMove questionnaire encompasses nine emotional categories to express how consumers feel while smelling an odor or a scented product: unpleasant feelings, happiness/delight, sensuality/desire, energy, soothing/peacefulness, hunger/thirst, interest, nostalgia, spirituality. Continuous scales appeared in the virtual worlds on a screen after the odor was delivered for 6 s for the 3D condition and on the computer screen for the 2D and 1D conditions. These scales appeared on the full computer screen in the 2D condition, whereas they appeared on a wall corner in the 3D condition. Immersion was therefore more disturbed in the 2D than in the 3D condition.

3.2 Results

This odor delivery device was able to provide fun and interactive experiences with different emotional responses in the iVR environment. From verbalization results, the two apples were associated with feelings of hunger/thirst and energy, whereas the tiare flower was associated with feelings of relaxation. Isovaleric acid and trash bin odors were most associated with feelings of disgust, whereas the two candles were most associated with feelings of happiness and relaxation and the chocolate was most associated with feelings of hunger/thirst (Fig. 3.3).

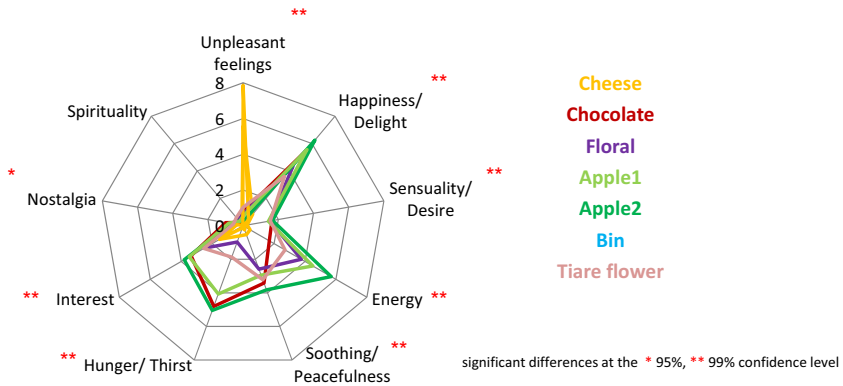


FIGURE 3.3 Emotional responses from verbalization for seven odors delivered in the kitchen environment.

From the psychophysiology measures, significant differences in respiratory volumes were observed for pleasant odors compared with unpleasant odors in the tramway and in the bathroom.

This experiment also showed that the scents were perceived differently in the different iVR environments from both verbalization and psychophysiology measures. Results from questionnaires demonstrated contextual influences on verbally reported emotional responses to odors. In general, the odors smelled in the kitchen environment were characterized as having higher levels of pleasant, mouthwatering, and amusement feelings and lower levels of disgust feelings, whereas the odors smelled in the bathroom environment were characterized as having higher levels of desire, energetic, and relaxed feelings (Fig. 3.4). In particular, isovaleric acid was the least related to disgust feelings in the kitchen environment when associated with cheese and the most associated with disgust feelings in the tramway when associated with a dirty-looking avatar. The tiare flower was more associated with interest, mouthwatering, and relaxed feelings in the kitchen and more related to energy and less to mouthwatering feelings in the bathroom. Lower feeling levels were obtained when the odor was not related to an object (i.e., in the tramway environment). However, despite these differences in verbally expressed feelings, no significant differences were found in skin conductance responses (arousal) and heart rate responses (valence) among the three worlds.

From the verbalization results, delivery of odors in the 3D virtual environments did not result in higher or more differentiated emotional responses (for the two apples, candles, and deodorants). In addition, the complexity of the virtual experimental settings made the psychophysiology recordings less accurate than for the two other conditions. Psychophysiology measures are influenced by participant activity and movements, and artifacts and loss of data for heart rate responses were obtained when the level of immersion

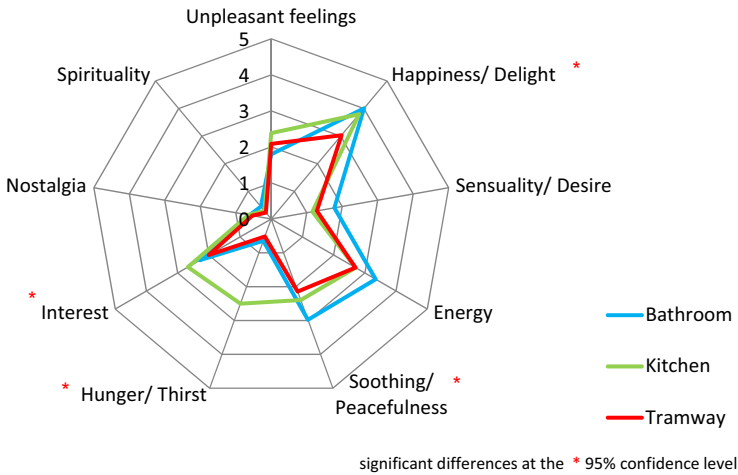


FIGURE 3.4 Average of emotional responses from verbalization obtained in the three environments.

increased (46% in 3D, 22% in 2D). From the electrodermal response (comparison of pleasant vs. unpleasant odor), significantly higher responses were obtained for the unpleasant odor ($P = .041$) and significantly higher responses were obtained in the 3D environment ($P = .017$), indicating more arousal. However, despite there being more arousal, this experiment did not show more elicited affective reactions, differentiation, or environmental influence from verbalization.

Finally, the 2D experimental settings appeared to be a good alternative to the 3D, with higher levels of feelings in general than with the two other conditions, except for the interest dimension, which was highest in the 3D condition. Participants also self-declared being more immersed in the 3D condition than in the two other conditions.

4. DISCUSSION (LEVELS OF IMMERSION, POSSIBLE BIAS, AND VALIDITY)

Immersive techniques, despite technical and cost constraints, seem to be a flexible and rapid way to place consumers into researcher-defined contexts and simulate the use or consumption of a product under controlled conditions. Such techniques have the clear advantage of allowing the manipulation of the contextual variables at play for higher internal validity and observation of their possible integrative effects on consumer behavior.

However, despite the fact that there was more arousal measured with psychophysiology recordings, no higher levels of feeling were verbalized compared with the lower levels of immersion. This observation raises the problem of whether the arousal level in the iVR experiment comes from the experience

or from the odor. Less strong feelings were also perceived in the tramway environment, which raises questions about the role of the objects in emotional elicitation in these environments. The avatars generated less expectation compared with the food objects present in the kitchen or bathroom. Moreover, as the exercise was new to the participants and they enjoyed the entertaining 3D experience, they might have paid more attention to the environments and the fun objective of the experience than to the odors that were delivered. The visual information might have been stronger than the olfactive information. The question is whether the odors would have more or less influence in natural-life situations.

Limitations are related to the nature of measures that could be conducted in iVR and how participants' feedback could be collected. For example, loss of physiological data was observed because of the participants' movements. The questionnaire approach is not ideal, because it disrupts the immersive approach and the multisensory experience. More observational approaches should be implemented in such immersive environments, which demand new tools and the implementation of implicit measurement techniques. Finally, the major technical constraints that the research community will need to solve are related to product testing and having consumers taste products while they are wearing glasses. Another serious constraint is the delivery of odors when an efficient olfactometer is not available. Finally, the 3D glasses isolate participants from any social interaction as would occur in real life.

Considering the constraints of iVR, perhaps fewer immersion levels would be enough, as observed in our study in 2D. Therefore, more studies need to be conducted to compare different degrees of immersion: on a computer screen or on larger screens compared with iVR. Authors have shown that it is possible to implement a plausible "moment of consumption" in a controlled setting with only a few environmental elements (Bangcuyo et al., 2015).

Finally, one could question the validity of these measures and the reality of these environments, which are not those that participants are used to in real life. One could also question whether these aspects need to be closer to those in real life, i.e., whether these contexts are realistic enough and relevant to consumers. New devices, such as 360-degree videos, could help to increase the impression of being close to real life. These videos could be adapted to virtual reality glasses and could immerse people in real environments that have been filmed (i.e., stores, bars, restaurants, tramways). Participants could still have a good level of immersion because the environments move with their heads.

There is no doubt that immersing consumers in close to real-life conditions may improve the ecological validity of consumer research performed in a laboratory. However, more studies need to be conducted to prove the external validity of these immersive techniques in comparison with real-life experiments (Jaeger et al., 2017). Would the contextual effects be comparable? Do the immersive approaches overestimate or underestimate contextual effects in comparison with what might happen in a real situation? To what extent are

immersive approaches able to provide new insights compared with more traditional approaches? How could this unique technology be used to address typical research questions about olfaction with regard to emotional elicitation, memory encoding, multisensory interactions, or attentional capture by scents? By using these approaches, sensory food consumer scientists could shift their attention more toward the role of incidental learning and implicit memory in food perception (Köster, 2009).

5. CONCLUSION

The technology of iVR is advancing every day and is no longer dedicated only to gaming. Instead of being passive, consumers could actively participate in a multisensory experience. Today, everyone is “connected” and the new generation cannot live without electronic devices and connected tools. The digital revolution has forever changed the way people behave, interact, consume, and shop. Augmented reality as a marketing platform reaches and engages customers in a new way. Virtual reality is also a good way to offer personalized services to travelers (i.e., allowing them to navigate a new city by recommending the best places to visit). New technologies also provide new ways to connect with consumers and to interact via social media platforms across multiple devices.

The digital revolution has changed the way consumers behave, and this implies that the sensory and consumer science field needs to think differently and adapt to this digital revolution. Although expensive and complex equipment in 3D laboratories was necessary in the past, progress in this field has made equipment more affordable (e.g., glasses from Oculus). iVR is therefore a part of these new digital tools that is becoming affordable and relevant to the new connected consumer generation. The iVR approach still seems futuristic, but it could soon become the most adopted approach in the study of consumers and their behaviors. Nonetheless, these are still niche approaches and more studies need to be conducted to prove the external validity of these immersive techniques in comparison with real-life experiments.

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Chapter 4

Evaluation of Meals and Food Pairing

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Chapter Outline

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1. INTRODUCTION

The importance of studying human sensory perceptions of food in context has never been clearer. As sensory evaluation and consumer research have matured, the need for research methodologies with greater ecological validity has become increasingly apparent (Lawless & Heymann, 2010). Our personal experiences, our social and cultural backgrounds, and the environmental and social contexts in which we eat have been shown, time and time again, to be at least as important as the physical food itself to our perceptions, experiences, and behaviors (de Castro, 2000; Meiselman, 1992).

Because human eating behavior is diverse, complex, emergent, and contextual—in other words, exactly like all human behavior—the paradigm of laboratory control is potentially suboptimal for studying it. Instead, as sensory scientists we should model ourselves after ethnographers and seek out food in its native environment, at meals and in the presence of other foods. Studying meals as a whole presents challenges in terms of control and statistical analysis, but the gain of ecological validity should be more

than a fair exchange. In this way, sensory evaluation can establish itself as a primary discipline for understanding human food-consumption behaviors (Köster, 2009; Mela, 1999, 2001), and as more than a collection of industrial practices (Peryam, 1990; Schutz, 1998).

1.1 Background

Sensory evaluation of food has an admirable and specific goal: “to isolate the sensory properties of foods themselves and provide [...] useful and important information” (Lawless & Heymann, 2010, p. 1). To this end, a fundamental principle of sensory evaluation is control: “[s]ensory evaluation gives guidelines for the preparation and serving of samples under controlled conditions so that biasing factors are minimized” (Lawless & Heymann, 2010, p. 2). The vast majority of sensory evaluation work, then, is conducted in laboratory settings that allow for this control: the subject is given very specific instructions, and observed and tested for compliance; the sample (in our case food) is prepared and presented so as to minimize “irrelevant” factors; the environment itself is controlled for variations in temperature, background aromas, light; subjects may not speak to each other; and foods are not eaten together (Lawless & Heymann, 2010; Meilgaard, Civille, & Carr, 2007; Stone, Bleibaum, & Thomas, 2012). In other words, sensory evaluation works very hard to create a tasting environment in which the human measuring instrument can be tuned and controlled (Muniesa & Trébuchet-Breitwiller, 2010).

This makes what goes on in a sensory evaluation very different from how foods are normally consumed (Hennion, 2015; Howes, 2015): in the presence of others and during a conversation, in many combinations, with distracted attention, without strict instructions or rules, and in uncontrolled (and often uncontrollable) environments. Sensory scientists generally agree that this trade-off is satisfactory (Lawless & Heymann, 2010)—it is impossible to adequately identify the sensory properties of the foods themselves if we do not eliminate the variation discussed herein with the controls just mentioned. Because the senses we most use to perceive foods (taste, smell, and touch) are chemical senses (and so objectively physical, see Martens, 1999), we can and should concentrate on the sensory properties that reside within the chemical and physical object.

As perhaps the previous syllogism hints, however, this is a deep philosophical statement about the nature of sensory experience rather than an axiomatic truth; the implication is that the sensory properties of foods are in the foods themselves. Without embarking on a disquisition on qualia and objective realism, suffice it to say that this is not an uncontested position. Current thought on the nature of perceptual experience in psychology (Köster, 2003, 2009), sociology (Chabrol & Muchnik, 2011; Hennion, 2015; Phillips, 2016; Shapin, 2012a, 2016), anthropology (Howes, 2015; Ingold, 2011 [2001], Sutton, 2014), and even neuroscience (Plassmann, O’doherly, Shiv, & Rangel, 2008) casts this assumption into some doubt. The perception of

the sensory properties of a physical object—a psychological event—can be influenced as much by cultural, social, temporal, and contextual factors as by the physical object of apperception (Cardello, Schutz, Snow, & Lesher, 2000). The 19th-century psychophysical model that has been in large part the basis for the sensory evaluation of food (Dalston & Galison, 2007; Lawless & Heymann, 2010), while fantastically powerful for exploring basic psychological phenomena, is probably poorly suited to actually explaining diverse groups of humans' experience of food in everyday life (Köster, 2009).

1.2 Meals and Food Pairing

This chapter provides an overview of two related topics within food-sensory research: meals and food pairings. More properly, food pairings can be thought of as a subset of research into the sensory properties of meals. Food pairings are particular cases in which foods or a food and a beverage, when consumed together, may present different sensory properties than when consumed alone. In actuality, this circumstance is usually encountered *in vivo* within a meal context. Therefore, many of the theoretical conclusions and methodological considerations that apply to one topic apply to both. However, because food pairings are in and of themselves of cultural relevance and importance—consider, for example, Chinese considerations of balancing “hot” and “cold” pairings or the Western preoccupation with pairing wine with food (Davidson, 2014; Mcgee, 2004)—they deserve their own consideration.

Both of these topics could constitute a chapter, or a textbook, on their own. Given the parameters of the current work, each topic will be presented with a brief definition and overview, a review of the state of research, and recommendations for best practices in research, taking particular note of the gaps in the current literature. Finally, the chapter concludes with a brief empirical case study of collecting sensory data from real meals from our own research group, in which we consider the challenges and potential of doing “real-meal” research.

2. MEAL RESEARCH

The necessity and challenges of making sensory evaluation “see” meals is not new; in the late 20th century, Meiselman (1992) wrote a prescient and forceful commentary demonstrating the need for a sensory evaluation sensitive to how people eat in the real world. For various reasons, discussed briefly earlier (see also Köster, 2009; Lahne, 2016), sensory evaluation has been slow to heed this call. One important additional reason is the sheer variety hidden in the simple term “meal”; when we gather to eat, humans around the world employ a bewildering (or perhaps inspiring) variety of food and drink combinations, table manners, presentation and cooking styles, and cultural mores (the literature here is vast, but for a nondefinitive introduction, see Carroll, 2013; Fernández-Armesto, 2002; Spence & Piqueras-Fiszman, 2014; Visser, 1991; Wilson, 2015;

Wrangham, 2009). Instead of grappling with this diversity, sensory evaluation has assumed that the “taste from nowhere” (to paraphrase Donna Haraway, 1988)—the standardized laboratory setting advocated by the discipline’s founders (Lawless & Heymann, 2010)—is universally relevant to foods in (meal) context.

Since Meiselman’s (1992) call, there has been some increased research into foods in real-meal contexts that generally contradicts this assumption. Much of this research has been driven by a paradigm inspired directly by Meiselman, that “three different classes of variables contribute to the appreciation of food: those variables related to the food itself, those related to the individual, and those related to the eating location and situation” (Edwards, Meiselman, Edwards, & Leshner, 2003, p. 647). However, we would argue that this quantization sells the meal short; what about variables related to culture or society (Adapon, 2008; Sutton, 2014), class (Bourdieu, 1984), or the diverse aspects of temporality (Cardello, 1995; Hitlin & Elder, 2007)? The number of variables we might examine when we begin to examine food within meals instead of “food as material” is vast and difficult to categorize neatly.

In an earlier naturalistic study, Sommer and Steele (1997) found that an aspect of the social context was directly related to mealtime behavior—time spent at a restaurant directly increases with the size of the group dining. Ariely and Levav (2000), in another naturalistic study, found that consumers eating in groups made different ordering choices than they might make otherwise, and that in fact they chose items they liked less to increase in-group variety. Thus, it is clear that the meal situation itself changes consumption behavior and food choice; it is also apparent that these conclusions are impossible from laboratory or single-food studies. Reinforcing this conclusion, Cardello et al. (2000) found that in vitro consumer reports of expected food liking were poor predictors of (simulated) meal situations, and that in fact contextual match or mismatch (in this case eating breakfast or nonbreakfast foods at inappropriate times) appeared to be more predictive of behavior than consumers’ own reported liking. The difference between laboratory and in vivo perception is reinforced by Petit and Sieffermann (2007), who demonstrate (with iced coffee as a case study) that both reported consumer liking and actual consumption behavior are different outside of the laboratory than within it, and that this difference is stable across multiple studies. Taken together, this research shows that how we behave during meals is very different from how we behave alone in labs.

In a series of studies, Meiselman and his collaborators (Edwards et al., 2003; de Graaf et al., 2005; King, Meiselman, Hottenstein, Work, & Cronk, 2007; King, Weber, Meiselman, & Lv, 2004; Meiselman, Johnson, Reeve, & Crouch, 2000) have shown strong and repeatable evidence that an assortment of contextual variables affect not only consumer behavior but also consumer perceptions. In the first study, Meiselman et al. (2000) demonstrated that consumers reported different liking ratings for identical food served in different settings (cafeterias, sensory labs, restaurants). This result was repeated by Edwards et al. (2003), with

the additional provocative implication that the class of the restaurant directly influenced consumer liking (i.e., a “nicer” restaurant produced greater reported liking). Two, larger studies by the same research group (King et al., 2004, 2007) demonstrated the persistence of this effect and emphasized that so-called “context effects” (social, location, and other diner-related effects) were not consistent across food items. Finally, in a related study, de Graaf et al. (2005) found that even ratings of the same food in laboratory and nonlaboratory situations by the same group (members of the US Armed Forces) showed poor correlations, although these could be improved by allowing subjects in the laboratory to choose which foods to rate, making the laboratory more like the real world. Overall, these studies tell us that the sensory properties of food seem to be emergent; they do not reside statically within the food but are a product of a particular food in a particular environment.

Demonstrating the effects of both intrinsic (production) variables and contextual (eating situation) variables on reported consumer liking for white wine, Hersleth, Mevik, Næs, and Guinard (2003) report that “the most striking finding regarding context in this study is that the size of the effects produced by the context variables was similar to ... the enological variables” (Hersleth et al., 2003, p. 621). In that case, the context variables included laboratory versus “reception” contexts, availability of food to taste with the wine, and whether socializing was allowed. Thus, not only are intrinsic variables philosophically difficult to define but they may not be any more important to the perceptual experience of the product than the meal context. Interestingly, researchers from the same group failed to find differences in liking for hard cheeses in different eating contexts (Hersleth, Ueland, Allain, & Næs, 2005). However, the researchers themselves cautioned that the research design in that particular study did not really allow the context to vary other than the location (laboratory, central location test, or home); the provided instructions made it very clear that the tasting was a test, rather than a meal, regardless of location.

From these studies it is clear that food eaten as part of a meal, outside of a laboratory context, is experienced differently by consumers than when it is eaten within the laboratory (de Castro, 2000), whether or not the laboratory is made to seem less controlled (Kim, Lee, & Kim, 2016; Petit & Sieffermann, 2007). Subjects make different choices, report different perceptions, and consume different foods (and quantities) in real meals compared to laboratory studies. Why might this be?

Many of the best explanations for these contextual differences are found in cultural anthropology, sociology, and other social sciences (as discussed briefly earlier)—areas that sensory science could productively explore and exploit to produce more accurate research into consumer sensory perception. A few studies within the discipline provide some hints about what this exploration might look like. For example, Wansink, van Ittersum, and Painter (2005) demonstrated that descriptive names in situations in which meals are purchased and there is an aspect of choice (i.e., restaurants, cafeterias, etc.) are assimilated into consumer

sensory experiences of the food itself; furthermore, this assimilation was more deliberate and active on the part of the consumer than is usually assumed in a “bias” model of food-sensory perception (e.g., that subscribed to by most sensory and consumer scientists). That is, consumers are “active subjects” (Hennion, 2007) who can and do learn to “taste” informational qualities based on their social and cultural backgrounds and previous experiences (Lahne & Trubek, 2014; Lahne, Trubek, & Pelchat, 2014).

A study from Mielby and Frøst (2010) provides further insight into the mechanism of this information assimilation. In collaboration with a professional chef, the authors developed an 11-course meal to be served in a banquet hall, and assigned diners in the meal to one of four conditions: they received dishes with only an allusive title (such as “salad roots and ‘ardent love’” p. 216), with the title and sensory descriptors, with the title and processing information, or with the title and hedonically evocative descriptions. The researchers found that for dishes that were universally liked, information had little or no effect on the reported experience of the dish, but that for dishes that elicited a more equivocal response, processing information in particular increased reported liking. This may be explained by the fact that the audience for the meal was particularly curious and involved in restaurant meals, and so probably found technical information enlightening and interesting, and thus more assimilable into their sensory experience of eating.

The Mielby and Frøst (2010) study is a good example of researchers successfully grappling with the challenges of collecting data without turning the meal context into a laboratory context. The deliberate strangeness of a “molecular gastronomy” meal may have helped to facilitate this intervention—subjects already expected the meal to differ from a normal restaurant or home meal, and so filling out questionnaires in-between courses is a minimal disturbance of the normal context. Given the trickiness of balancing experimental control, ecological validity, and the need to intervene to collect data, taking advantage of such situations is a critical part of designing effective meal-research studies. We have found (as discussed in the following case study) that working with teaching restaurants (at a culinary school) provides a wonderful opportunity to control the meal without completely disrupting the meal context (see also, for example, Porcherot, Petit, Giboreau, Gaudreau, & Cayeux, 2015).

2.1 Good Practice in Meal Research

From these studies, we can derive some basic principles of good practice for conducting consumer-sensory research into actual meals. First and foremost, it would behoove research into meals to actually employ meals; this simple fact, championed by Meiselman (1992) several years ago, is still too often neglected in practice. It is important for data collection methods to be unobtrusive and not to accidentally cause a meal to turn into a laboratory feeding. This could involve (although it does not require) moving beyond sensory

and consumer sciences' usual approaches of questionnaire-based self-reports to behavioral or indirect methods. Finally, sensory and consumer scientists should remember that they are (usually) not professionals in the field of meal production; working with chefs, waiters, bartenders, and other professionals can produce better results than assuming that we can adequately simulate a real-meal situation.

The most important principle for conducting meal research is to study actual meals, as people actually eat them, and not isolated foods in isolated sensory booths. While often these studies will have to involve some aspect of artificiality (a limited menu in restaurant studies, providing specific foods to participants in home use tests, etc.), limiting that control will increase the validity of the studies. As [Meiselman \(1992\)](#) and [de Castro \(2000\)](#) argued decades ago, there is a host of reasons to actually study real meals, rather than laboratory feeding occasions. [Meiselman \(1992\)](#) puts forward a number of reasons laboratory feeding is a bad model of human food-related behavior: subjects are compelled to eat, limited by specific instructions, given no or very constrained choices in their foods, studied only in the short term, and assumed to be rational and consistent in their choices over the long term based on this short observation. [de Castro \(2000\)](#), a nutrition researcher, raised another host of objections to the lab as representative; as well as reiterating a number of [Meiselman's \(1992\)](#) considerations with new and different examples, de Castro argued that both inhibitory and facilitative influences on eating that are present in the real world are absent in the lab. Even more critically, while experimental control is usually thought of as a boon for establishing causation and obtaining evidence of large effect sizes, de Castro claimed that this is a misunderstanding, and that the laboratory actually inflates effect sizes and is a possible source of spurious conclusions about causation, because it is so different from reality. Finally, he argued that the “multivariate richness” of real-world environments, rather than being a barrier, is a benefit to research: “all the researcher has to do is observe and measure[, t]here is no need to anticipate in advance what may or may not be important and then arrange the environment to isolate the factor” ([de Castro, 2000](#), p. 807).

Hand in hand with limiting the experimental or artificial context are considerations for how to actually collect data. In laboratory studies this is a trivial matter because part of the instructions for participants is how to compile and submit their responses. In everyday meals humans rarely explicitly report on what they are consuming—they eat, talk, perhaps consider the sip of wine they have just taken briefly and privately, and then return to their meal, conversation, or both ([Hennion, 2015](#)). In order not to disturb this cozy scene, the most common method for accessing perceptions of meals is through postmeal self-reports, as in the study of perceived variety in meals by [Haugaard, Brockhoff, and Lähteenmäki \(2016\)](#), in which researchers photographed subjects' meals after they had composed plates freely at a commercial buffet, and then asked them questions about how they perceived variety within their meals after they eaten. While this has its limitations (self-reports can be biased, subjects may

not recall accurately), methodologists have argued that these noncoercive self-reports can be more than adequate (de Castro, 2000), and self-report data have been extensively useful (e.g., Bisogni et al., 2007; Blake, Bisogni, Sobal, Jastran, & Devine, 2008). However, given the reasonable doubts about whether self-reports can actually capture the experience of the meal, it is worth considering other approaches. Roughly, there are two routes that can be taken: observational methods and novel questionnaire-based methods.

Rather than requiring subjects to break out of their context (the meal), introspect, and provide self-reports, it might be preferable to record nonintrusive observations that capture their sensory experiences (Köster, 2009). For example, one might be so hands off as to collect receipts from an actual restaurant to determine what was eaten (Ariely & Levav, 2000) or weigh plates to determine how much food was consumed—a proxy for liking. Meals can be audio or video recorded and transcribed and then coded for reference to the meal itself to gain insight into the sensory experience of the participants (e.g., Wiggins, 2001). It is even possible to prompt subjects to verbalize and discuss their experiences while eating, for example, in a focus group setting (Lahne & Trubek, 2014), to maintain some guided control while not completely disrupting the communal and free-flowing meal situation. Observations can, of course, be combined with pre- or postmeal questionnaires to determine whether covariates should be considered, for example, hunger level before and after the meal or liking for particular food types. Observational data present their own challenges—they may be qualitative rather than quantitative, require larger sample sizes to generate convincingly reliable conclusions, and so on—but they also have the advantage of being as ecologically valid as possible and allowing, as de Castro (2000) emphasizes, for important variables to emerge, rather than requiring the researcher to anticipate them.

Developments in computer (and especially tablet and cell phone) technology have also opened novel avenues to collecting questionnaire data during meals without requiring resorting to more disruptive paper instruments. So-called “big data” has the potential to provide insight into eating behavior and potentially perception (discussed briefly under Good Practice for Food-Pairing Research), but because this requires a long methodological discussion of its own, it will not be a focus here. More relevant for the current discussion, cell phone and computer usage has become increasingly frequent during all but the most formal meals (Alajajian et al., 2015), and so surveys can be sent to these devices or to small tablets provided by the researchers during meals and potentially be much less disruptive than the distribution and collection of questionnaires. It is, for example, possible to create distributed research projects modeled on descriptive experience sampling (Hurlburt & Akhter, 2006) or related methods, in which participants are given either a phone or tablet or a program for their personal device that prompts them to answer a questionnaire at randomized times as they go about their life outside the laboratory. Questionnaires can be customized to relate to food experiences and be triggered during random expected meal

times. To our knowledge such a method has not been implemented in sensory or consumer research, and this method would present a fantastic opportunity to capture fully representative meal-time experiences.

Finally, it is imperative that sensory or consumer scientists working with real foods and meals incorporate subject matter experts into their study design. For example, when designing a restaurant meal study, it is important to involve the chef, cooks, and waiters as one considers how foods will be prepared and served, and how data will be collected. As researchers we discount these considerations in the laboratory because we assume that the material object is the important thing; but because it is hoped that this chapter has deconstructed that assumption, it should be obvious why working with professionals is helpful. It may take effort to get them to understand the needs of the research and the restrictions that conducting research introduces, but as we discuss in the chapter's case study, these efforts will be amply rewarded by the knowledge of the food, context, and subjects that these professionals bring with them.

3. FOOD PAIRINGS

One explanation, although probably not the likeliest, for the remarkable differences between how consumers perceive and behave toward food in the laboratory and in the real world might be some sort of chemical or psychological synergy between the actual foods eaten. This synergy is referred to in both popular and scientific literature as “food pairing.” It is likely that the concept of “pairing” comes from concerns over which food goes with which wine (DiDio & Zavatto, 2003). Knowledge of such pairings was part of the knowledge that defined Western upper-class society, to which one might aspire (Bourdieu, 1984; Shapin, 2012b), and so being able to pair food and wine became a subject of valid concern for research. Other beverages and foods—beer, chocolate, cheese—that have become prestigious objects of consumption have followed in this paradigm. This historical evolution of food-pairing studies is supported by the simple observation that most studies of food pairing concern wine.

The earliest reported study of food pairings is that of Eindhoven and Peryam (1959). In it, the authors collected subjects' self-reported liking ratings for foods by themselves and then liking ratings for pairs of the foods. They found that the foods' solitary liking ratings were not predictive of how much pairs of foods were liked; there was a significant nonadditive or synergistic effect, in which pairings resulted in unpredictable changes. This result is in contrast to many subsequent papers that found that individual liking for one element of a pair was strongly (although not solely) predictive of liking for the pairing. However, as discussed later, this may be due to methodological rather than actual differences. Unfortunately, one part of the study was strongly in concordance with subsequent studies; despite the strong ties between food-pairing and meal research, the vast majority of food-pairing research has been conducted under laboratory conditions, which as described before presents a significant barrier

to translating the results of such research to real-world experiences of food pairing. In the case of this particular study, foods were not actually presented to the subjects, which may further weaken the study's conclusions.

There have been a number of studies that seek the roots of food pairing in chemical composition. [Tamura et al. \(2009\)](#) demonstrated quite convincingly that “fishy aftertaste” in wine consumed with various seafoods was related to the ferrous iron concentration in the wine, and therefore white wines, which contain less iron, are a better pairing than reds. Similarly, [Fujita et al. \(2010\)](#), seeking to explain (or justify) sake as a superior pairing for fish, showed that sulfur dioxide, which is used in wine production but not in sake, can lead to fishy off-flavors when consumed with seafood. There are other papers of this genre (see the review at the beginning of [Harrington & Hammond, 2005](#)), but they are generally unable to conclusively declare which wines should or should not pair with which food, largely because of the philosophical confusion, alluded to earlier, over whether sensory perception is inherently chemical (and therefore physical) in nature. For example, the convincing evidence of the papers on fishy off-flavors ([Fujita et al., 2010](#); [Tamura et al., 2009](#)) does nothing to explain why a number of red wines based on the pinot noir grape are known to be excellent pairs with salmon, a fatty fish ([DiDio & Zavatto, 2003](#)). Holistic approaches to food pairing are clearly needed. [Pettigrew and Charters \(2006\)](#) showed that consumers are aware of and interested in food pairings, but that the nature of food pairings and their expectations varied for even superficially similar products, like beer and wine.

Unfortunately, many holistic approaches are insufficiently thought through—they generally seek to measure “pairing” directly through the use of psychometric scaling. Yet the same papers note that while the idea of “food pairing” is widely accepted, it is poorly defined (e.g., [Harrington & Hammond, 2005](#)). So asking subjects to rate pairing directly is a doomed project (as is done in the study by [Harrington & Hammond, 2005](#))—there is no guarantee that two subjects are assessing the same construct. In that study, the authors found that sweeter wines paired better with less-sweet cheeses; however, the experimental design was so questionable that it is difficult to rely on the results. There are two main methodological problems with the study. First, the subjects did not replicate their ratings, making it impossible to estimate variance in their reported perceptions and therefore the reliability of their ratings. Second, the subjects were trained panelists and experts, used to working analytically, who were asked at the same time for their hedonic perceptions of the wine–cheese pairs. Considering that trained panelists are distinct from the general population, it is unlikely that their hedonic preferences are representative of those of consumers ([Lawless & Heymann, 2010](#)).

An equally problematic approach is taken in a number of studies ([Bastian, Collins, & Johnson, 2010](#); [Donadini, Fumi, & Lambri, 2012, 2013](#)), apparently stemming from research conducted by [King and Cliff \(2005\)](#). These studies treat pairing as a function of which food “dominates” the combination. The

explicit assumption is that in an ideal pairing neither food's taste is more "dominant" (presumably "powerful"). In all of the studies, a modified just-about-right (JAR) scale (Lawless & Heymann, 2010) is used, with end points labeled "[Food X/Y] dominates extremely" and the center point labeled "ideal match" (King & Cliff, 2005). The basis for this construct of pairing is "conventional wisdom," although only one source is cited for this wisdom (King & Cliff, 2005). In fact, logic would dictate against this particular construction; if pairing is a synergistic interaction between foods, then equi-intensity has nothing to do with the emergent quality of the pair. The dominance construction implies that instead food pairing is merely an additive phenomenon that emerges when one food is not drowned out by the other—a direct contradiction of both the chemical (Fujita et al., 2010; Tamura et al., 2009) and the previous psychological (Eindhoven & Peryam, 1959) research without a cogent justification.

The results of this research are unsurprisingly equivocal. The study by King and Cliff (2005) found that sweetened or fortified wines were harder to pair with cheeses, which directly contradicts the results of Harrington and Hammond (2005). Bastian et al. (2010) found that for consumers there was no correlation between these dominance ratings and reported likings of pairings between Australian shiraz and cheddar cheese, although there was a strong correlation between both consumer and expert quality and liking ratings and the liking of the pair. Similarly, Donadini et al. (2012) found that with chocolate of varying cocoa content and a range of beverages, dominance was not predictably related to liking; effect-size analysis of the complex design showed that dominance level had only a small effect on reported liking for the pair, and different pairings showed different preferences for the direction of dominance. In the study by Donadini et al. (2013), consumers seemed to strongly prefer beer and cheese pairings in which the cheese dominated strongly, and disliked so-called "harmonic" pairings (an "ideal match" according to the JAR paradigm). Research that employs the dominance paradigm does not seem capable of explaining food pairing.

More productive results have come from analytic approaches, usually based in descriptive analysis (DA), that focus on how the specific sensory attributes of a target food are changed by pairing with another. For example, Madrigal-Galan and Heymann (2006) designed a DA study in which judges first evaluated the sensory attributes of eight red wines by themselves, and then again after tasting each of four cheeses. The researchers found that, while each cheese significantly affected certain sensory attributes (reducing astringency, for example), there was no wine–cheese interaction effect, meaning that the effect of each cheese was the same for all wines. Furthermore, while the effects were statistically significant, they were relatively small in absolute terms. The DA portion of the research conducted by Bastian et al. (2010) confirms these results; shiraz wines consumed after cheddar cheese generally showed lower astringency and acidity, with somewhat higher fruit aromas. In the research by Donadini et al. (2013) on beer pairings, DA of beers preceded by parmigiano resulted in lower intensity ratings for most attributes, although the patterns seemed to vary by

beer; in particular, and agreeing with the previous research, bitterness, astringency, and carbonation level were affected, as well as “maltness,” which is distinct from the wine research. Overall, this analytic approach has been more productive (although necessarily more limited), and we can make some statements about the actual sensory changes that emerge from tasting foods together, albeit only under artificial laboratory conditions.

Thus, food-pairing research is ripe for methodological innovation. On one hand, analytic approaches focused on chemical or descriptive changes have produced results that are convincing but narrow, and are in need of testing in real-meal situations. On the other hand, research that has attempted to make this connection to actual, consumer perception has largely been hampered by missteps that lead to contradictory and unconvincing conclusions. Furthermore, the focus on beverage–food pairings has largely ignored all of the other types of pairings that can occur in meals; for example, chefs from many cuisines, operating often on implicit or unelucidated principles, use principles of food pairing to compose plates that delight and surprise the palate (e.g., [Mielby & Frøst, 2010](#)). If sensory and consumer science could contribute to the understanding of how these choices operate, it would be a major step forward for the field.

3.1 Good Practice in Food-Pairing Research

As of this writing, the research into food pairing is too sparse to provide a complete guide to good practice. However, there are a few obvious principles that should lead to better, more productive research into this intriguing phenomenon. Most importantly, of course, food-pairing research should whenever possible be conducted with the same considerations as research into meals in general, as described previously. Almost as importantly, however, is the need to better define what food pairing is and how it should be measured; the current measures and constructs clearly are not adequate. Finally, as with meals in general, alternative methods of data generation and collection should be considered, as they may provide both new and better insights into food pairing than the current approaches.

Research into food pairing should be conducted with actual foods, in actual meal situations. As has been reiterated so many times in this chapter, food-sensory experience seems to be a stubbornly emergent phenomenon; it follows that food pairing, while certainly rooted in the same physicochemical bases as the rest of flavor, would be at least as emergent. Therefore, it makes more sense to locate the study of food pairings in the place where foods and drinks are most often paired—together, in real-life situations (or as best as we can approximate while still obtaining data). All of the considerations and advice in the best practices section for meal research are applicable in this pursuit.

A review of the available food-pairing research indicates that, while the idea of “food pairing” is widespread and commonly accepted, by both sensory researchers and the broader public, an exact definition is elusive. An important piece of research, then, is to provide a better definition for the construct. The

main point of conflict seems to be between whether food pairing indicates a balance of intensities between two foods (the dominance construct) and whether food pairing is a synergistic relationship between two foods. An obvious route, but one that seems to have largely been unexplored, is to evaluate foods that are broadly held to be good pairs to determine how liked they are individually, how intense they are individually, and whether either liking or specific sensory attributes change synergistically when they are consumed together. This would provide some basis for theorizing food pairing.

Defining “food pairing” better goes hand in hand with constructing better tools to measure it—a casual familiarity with psychometrics is enough to determine that the current tools for measuring food pairing are inappropriate. We would argue that the best path forward for research into food pairings is to follow good sensory-evaluation practice, and to be careful in the design of studies that combine analytic and affective judgments; too many of the current studies ask trained panels to make affective judgments, which may result in nonrepresentative results (Lawless & Heymann, 2010). If we accept the popular conception of food pairing as a synergistic interaction of foods, there is no reason to ask consumers to explicitly judge whether a particular pairing is good. Rather, a successful pairing should cause a nonadditive increase in liking over the individual components (as in Eindhoven & Peryam, 1959). The identification of a food pairing by this affective measure then could be subjected to a DA designed more or less as in Madrigal-Galan and Heymann (2006) to determine whether there is an identifiable change in sensory attributes that explains the change in liking. Conversely, if the dominance paradigm is accurate (which is unlikely, based on the evidence), DA can be used to identify theoretically good pairings, which can then be checked for increases in liking in consumer tests (note that this is more or less the approach in the study by Donadini et al. (2013), and that the results argue strongly against dominance explaining food pairing). Most importantly, however, consumers need to stop being used as the basis for dominance-type sensory evaluation until such a paradigm is validated as actually capturing food pairing, as described earlier.

So-called “big data” research has, as hinted at previously, opened some fascinating possibilities for food-pairing research. Briefly, this type of research uses large sets of data that are increasingly available from multiple sources (digitized book and newspaper databases, Internet forums, social networks, user data from technology and health care companies, etc.) to power statistical methods that were previously not feasible because of sample-size considerations. For example, Ahn, Ahnert, Bagrow, and Barabási (2011) used recipe database information from Western and Asian sites to compare how often different ingredients are used together, and to determine whether reported volatile constituents of those ingredients might explain their pairing. They found that overall Western recipes used ingredients with shared volatile profiles, whereas Asian recipes used ingredients with differing volatile profiles. This provides some provocative (although not definitive) insights into the way that “food pairing” may

operate (differently) in different cultures. However, as all researchers involved were data scientists, and not food or consumer researchers, a number of misunderstandings may have driven the interpretation. For example, the researchers concluded that δ -lactones of different chain lengths had distinct sensory characteristics, which is contrary to the general understanding within flavor chemistry. Similarly, the “Chef Watson” project from IBM (Firth, 2015) uses recipe and ingredient-pairing data sets (as well as user feedback in terms of hedonics) to suggest novel recipes. It is clear that this sort of data, which is only just beginning to be tapped for sensory research, is of huge potential for both food-pairing research specifically and sensory and consumer research in general.

A note of caution—given that different cultures have different concepts of food pairings and meal construction, it is likely that food pairing is culturally (and cuisine) specific. It is unlikely (unless food pairing is a strictly physico-chemical phenomenon), for example, that cultures in which wine and/or cheese consumption are uncommon would get much benefit from a wine and cheese pairing that in a French context is judged to be sublime. The research from Ahn et al. (2011) reinforces this caution; in their data set what constitutes an adequate ingredient pairing is different between the Asian and the Western recipe sets. Therefore, as much as possible food-pairing research should be replicated in different cultural contexts to determine what is a “social fact” and what, like the potential degradation of fish fatty acids by iron in red wine (Tamura et al., 2009), is likely to be universal.

4. CASE STUDY: CONTRAST EFFECTS IN REAL MEALS

4.1 Introduction

In this section, we summarize a simple case study of meals in a restaurant context. The full study is reported in the publication by Lahne and Zellner (2015).

Recently, we were confronted with an apparently simple question: In a typical, three-course American meal in which small dishes (“appetizers”) precede a main course (Carroll, 2013; Visser, 1991), why is the main course so often a disappointment? Even at very fine restaurants, where clearly there should be no expected, objective decrease in the quality of ingredients or cooking between courses, this effect is anecdotally noticeable, both in our personal experience and in popular media (e.g., Wells, 2015).

One hypothesis that might explain this phenomenon is that a hedonic contrast effect is occurring because of the structure of meal. Contrast effects, very generally, are a group of psychological effects in which sequential presentation of stimuli affects the perceived strength of a target stimulus (as originally identified in concept by Fechner, according to Beebe-Center, 1965 [1932]). Hedonic contrast in particular is this phenomenon when it occurs with affective judgments of liking, for example, if a set of models’ faces are presented as conditioning stimuli, subjects will rate the relative attractiveness of a normal

(nonmodel's) face as lower than if that face were presented on its own (Cogan, Parker, & Zellner, 2013; Zellner, Loss, Zearfoss, & Remolina, 2014).

In the case of food served in coursed meals (usually in restaurants), the hypothesis is that the appetizers, which are generally more daring, piquant, and flashy dishes (Wells, 2015) act as conditioning stimuli, and so the main dish, which is often more conservative in style (Carroll, 2013), may suffer in affective judgments in comparison.

4.2 Materials and Methods

To test this hypothesis, we decided to serve experimental meals to subjects in as close to a restaurant context as possible. For hedonic contrast to occur, there has to be a difference in liking between dishes. Therefore, we designed two meals: one in which both the appetizer and the main course were of mediocre quality (no contrast), and one in which the appetizer was of excellent quality, but the main dish remained mediocre (contrast). The design, with pictures of the final dishes, is in Fig. 4.1.

To turn this design into a workable experiment, we engaged with Drexel University's culinary arts program, which runs a teaching restaurant called the Academic Bistro in Philadelphia, Pennsylvania, USA (Fig. 4.2). To have sufficient experimental control, the challenge was to come up with an appetizer that could be served in two versions (good and mediocre), without changing fundamentally. In this situation, input from the chef and the hospitality director of the Academic Bistro was necessary. Together they provided two versions of three different American-Italian appetizers: *arancini* (fried rice balls), chicken wings,

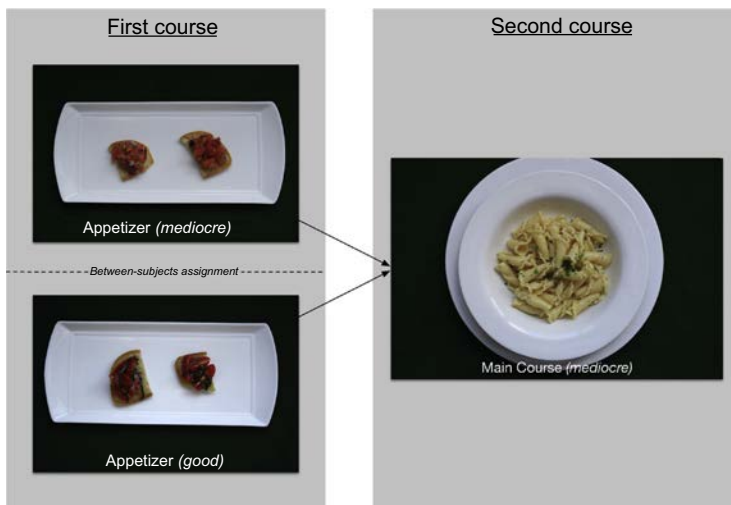


FIGURE 4.1 Diagram of study design and pictures of courses served.



FIGURE 4.2 The Academic Bistro at Drexel University.

TABLE 4.1 Meal-Item Ingredients		
“Good” appetizer: <i>bruschetta</i>	“Mediocre” appetizer: <i>bruschetta</i>	Main: <i>pasta aglio e olio</i>
Tomatoes (cherry)	Tomatoes (hard roma)	Pasta (barilla <i>campanelle</i> , cooked)
Garlic (minced)	Garlic (minced)	Olive oil (extra virgin)
Red onion (brunoise)	Red onion (brunoise)	Garlic (minced)
Olive oil (extra virgin)	Olive Oil (blended)	Water
Salt (to taste)	Salt (minimum)	Salt (minimum)
Pepper (to taste)	Basil (dried)	Parsley (fresh)
Basil (fresh)	Baguette (sliced 1/8 inch thick, toasted)	
Balsamic vinegar		
Lemon zest		
Baguette (sliced 1/8-inch thick, toasted)		

and *bruschetta* (seasoned tomato on toast squares). They also produced three different candidate main dishes: pasta with a basil pesto, tomato sauce, and *aglio e olio* (garlic and oil). We piloted these dishes with students and instructors from the Bistro; the pasta *aglio e olio* was the most hedonically neutral (mediocre) main, and the *bruschetta* showed the largest difference between mediocre and good preparations. The chef prepared standardized prep lists for the dishes (Table 4.1).

For the actual study, we recruited students, faculty, and staff from Drexel University through email lists for a free meal with a fixed menu at the Academic Bistro. Because the Bistro is used normally for training chefs, such meals are relatively common, and while we informed subjects (by IRB requirement) that they were taking part in research, we told them that we were pilot-testing recipes. Because the *bruschetta* appetizers were obviously different, the study was designed as a between-subjects test on separate Tuesdays (Fig. 4.1) so that subjects, who were not allowed to change what they received for the meal (e.g., add salt or otherwise change the taste of the dishes), could not see both experimental treatments. Thus, on Day 1 subjects ($N=35$, 27 females) received good *bruschetta* and pasta *aglio e olio*, and on Day 2 subjects ($N=29$, 21 females) received mediocre *bruschetta* and pasta *aglio e olio*.

Working with the chef of the Academic Bistro was also essential for maintaining consistency in experimental treatments; because food is cooked to order in a restaurant meal, rather than provided from a buffet or opened from packages, there is more potential for variation. Trained chefs are expected to produce the same dish multiple times during service, for many weeks at a time (Labensky & Hause, 2007). With the chef's help, we were able to turn out both consistent appetizers within the days on which they were served and consistent pasta across both days of the experiment.

We collected data using paper questionnaires both before and after the meal. Before the meal, we asked participants demographic details, whether they worked in the restaurant industry, how often they ate out at restaurants, and how hungry they were before the meal (on a scale of 1–10, with 1 being not hungry at all). After the meal, we asked participants to rate how much they liked both the appetizer and the main course using bipolar scales with -100 indicating maximum disliking, 0 indicating neither liking nor disliking, and $+100$ indicating maximum liking. We also asked how much participants were willing to pay for the dishes in an actual restaurant, how appropriate the dishes were to be served together, and how hungry the participants were after the meal on the same 1–10 scale.

4.3 Results and Discussion

Because the data showed significant nonnormality (as is common for hedonic ratings), we analyzed results using the Mann–Whitney U test, which makes no distributional assumptions. Accordingly, effect sizes were calculated as Cliff's d (Cliff, 1993). Participants in the different conditions did not differ in hunger before the meal; interestingly, participants in the good-appetizer condition indicated that they were slightly less hungry ($M=3.60$, $SD=2.29$) than participants in the mediocre condition ($M=4.59$, $SD=2.24$), although the effect only bordered on statistical significance (Mann–Whitney $U_1=379$, $U_2=636$, two-tailed $P=.08$, $d=0.25$).

Participants did indeed like the good appetizer ($M=72.40$, $SD=32.40$) better than the mediocre one ($M=59.38$, $SD=36.83$; Mann–Whitney $U_1=376$,

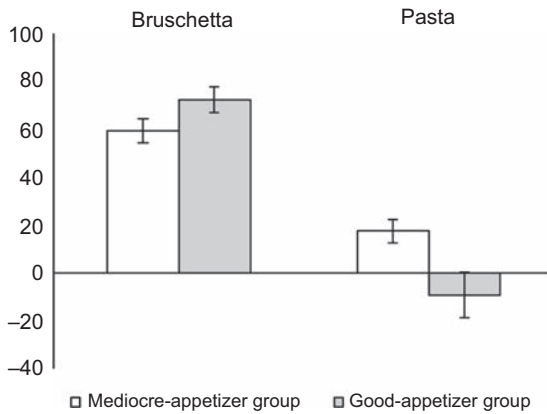


FIGURE 4.3 Mean liking for appetizers and main dishes by experimental group.

$U_2=639$, one-tailed $P=.04$, $d=0.26$). Other measures also indicated that participants thought the good appetizer was of higher quality than the mediocre one (see Lahne & Zellner, 2015).

With a number of measures we found that participants who received the mediocre *bruschetta* did in fact rate their pasta dish as significantly better ($M=17.41$, $SD=42.19$) than those who received the good *bruschetta* ($M=-9.28$, $SD=56.64$; Mann–Whitney $U_1=366.5$, $U_2=648.5$, on-tailed $P=.03$, $d=0.28$). The results are shown in Fig. 4.3. Participants also indicated that they found the mediocre appetizer to be a more appropriate pair for the (mediocre) pasta dish, although the effect was just shy of statistical significance ($M=6.00$, $SD=2.74$; Mann–Whitney $U_1=373.5$, $U_2=641.5$, one-tailed $P=.07$, $d=0.26$). No other measures related to the main course were statistically significant.

Overall, the data suggest that hedonic contrast does indeed play a part in the phenomenon of interest; in a coursed meal, initial courses can negatively affect the perception of subsequent courses if they are significantly different (better) in quality. This has significant bearing on how restaurants design the menus they serve, as the main course is likely to be of great impact in overall consumer evaluation of the meal. Further research will need to be done to determine whether this effect can be replicated and when it is attenuated (for example, past research would suggest that sufficiently “different” dishes should not cause these hedonic contrasts, see Zellner, Rohm, Bassetti, & Parker, 2003).

More importantly for the purposes of this chapter, this research demonstrates the potential of meal research and one potential methodological approach. Here, we worked with a restaurant willing to accommodate our experimental needs (restaurants do not usually serve mediocre dishes on purpose!) and with professional staff with the knowledge necessary to conduct the study. By keeping the research within an ecologically valid context, the results are more readily applicable to real-world situations.

5. CONCLUSIONS

In this chapter we have discussed two important, related areas of food-sensory research: meals and food pairing. We discussed the previous research in this area and some of the historical context that explains why these areas are just now emerging as foci in the consumer and sensory science fields. We provided some broad methodological suggestions and highlighted potentially productive areas for research. Finally, we discussed a short case study in which we conducted research on meals in a real restaurant context. The intent of this chapter was to provide readers with an overview of the field, to outline pitfalls to be avoided, and to provide some productive advice for future research.

Overall, as research areas, meal context and food pairing both present a great deal of potential, with the usual accompanying challenges. Although we as sensory scientists have recognized the importance of the meal context for decades, we have done too little to move our research out of the lab and into the dining room, so to speak. The evidence that meals do matter is now too strong to ignore, and by making such a move we can produce results that are stronger and more convincing than ever before. However, in doing so we will have to give up some of our attachment to experimental control and to complete certainty, and adopt both theory and attitude from social science, which tells us that human behavior (including eating and perception) is complex, contextual, and contingent, but that we can still draw objective conclusions from carefully designed research. Happily, the emergence of new tools and methods, like ubiquitous computing and big data research, are showing potential to help us manage this new and intimidating terrain. Although moving beyond the lab is challenging, it will ultimately make sensory and consumer science stronger and more powerful.

ACKNOWLEDGMENTS

I would like to thank Hildegard Heymann for her advice and comments while writing this chapter. I would also like to thank Chef Richard Pepino and Hospitality Director Paul O'Neill at Drexel University's Academic Bistro for their contributions as described in the case study.

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Chapter 5

Situational Factors and the Design of In Situ Evaluations

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Chapter Outline

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1. INTRODUCTION

The evidence for the effects of context on consumer perception and behavior has been widely demonstrated, raising many questions for consumer sciences. Context is always described as a fundamental dimension of eating, should it be regarding the pleasure of the meal as a whole (Meiselman, 2009) or its relation to culture (Fischler & Masson, 2007), psychology (e.g., Köster, 2009; Shepherd & Raats, 2006) or physiology (Blundell & Bellisle, 2013).

From a theoretical point of view, research in cognitive psychology has largely helped to identify factors and processes influencing perception and action (behavior) and continues to bring useful knowledge. The role of context is a complex question, as many factors contribute to the ecology of a situation: physical (spatiotemporal and environmental), social (human interactions and language), and individual (mental and physiological). For the consumer, all dimensions are integrated in a holistic picture of the context.

From a methodological point of view, it is not possible to control all contextual parameters because of the high number of factors, modalities and interactions. As a consequence, more and more consumer studies are conducted at home to bring context into evaluation tests. However, the wide variability in

usage conditions brings “noise” to the variable of interest and may reduce the outcome of the results.

Thus, consumer scientists and professionals look for intermediate ways between real-life and laboratory conditions to improve the ecological validity of experimental environments. Designing more realistic conditions should be realized at a reasonable cost and within an acceptable time frame. As presented earlier in Chapters 2 and 3 of this volume, evoked contexts or virtual environments are possible ways to bring context. Those approaches are based on representations of context rather than providing a real environment. In the present chapter, two alternatives are proposed to provide real settings and conduct in situ evaluations: (1) make the laboratory be a real-life situation (living lab) or (2) make a real-life situation be a laboratory (field experiment).

First, a series of key points is addressed with the aim of helping scientists select in situ testing conditions in relation to the objective of the test. Second, the living lab approach is detailed as an environment specifically designed to conduct consumer tests in real-life situations. Third, a methodological approach to the field experiment is presented to conduct investigations in real-life situations, with a particular emphasis on critical parameters to have under control.

2. KEY POINTS TO DESIGN CONTEXTUALIZED CONSUMER STUDIES

The most important thing to keep in mind when designing an in situ study is to consider all dimensions of context and not focus only on environmental ones. [Table 5.1](#) presents some of the most relevant elements to consider.

The wide range of examples given in [Table 5.1](#) illustrates the impossible task of creating controlled contexts for consumer tests if all factors have to be identical or balanced between subjects.

Conducting consumer tests in a laboratory means to define fixed parameters for physical factors on one hand and to minimize social and individual factors on the other hand. Lab tests are useful to compare products at the sensory level but they hardly explain between-subject differences in hedonic data. Most consumer studies end with clustering data, and unfortunately they rarely identify actionable criteria to characterize subjects in the different clusters. Defining targets corresponding to each taste group becomes a real challenge for marketing teams. Rather than explaining differences between targets after a hedonic test, it is thus useful to describe the variety of consumers before the test. On one hand, ethnography allows one to better understand consumer segments in relation to their specific practices. On the other hand, observational methods bring useful information to marketing to segment the market. However, when the question is to evaluate or compare products, no ideal situation is known to cope with both the constraints of controlling the context and the constraints of dealing with variable subjects.

TABLE 5.1 Categories of Contextual Factors Potentially Influencing Consumers' Responses		
Category of Factors	Subcategory	Examples for the Food
General context	Geography	Regular, occasional location
	History	Unique/repeated event, celebration, holiday, routine
	Economy	Paid, free, gift, brand
Physical context	Space	Size of the plate, distance to other subjects, size/volume of the room
	Time	Time of day, duration devoted to eating
	Atmospherics	Light, temperature, noise/music
	Meal structure	Food eaten before or simultaneously (side dish, sauce, bread), beverage drunk before or simultaneously (water, soda, wine)
	Delivery	Container (color, shape, volume, weight, material), cutlery
Social context	Interaction at service	Verbal and nonverbal interactions with the staff or person in charge of the food, waiting conditions (queuing, talking)
	Interaction at table	Links with other guests (friends, family, colleagues)
	Information	Language, label, price
Individual context	Culture	Region, generation, education, economics
	Knowledge	Familiarity with the product or the brand, general liking of the culinary category
	Personality	Sensitivity to risk, to reward, to affect; neophobia
	Motivation	Status of the meal for the subject—emotional value, attention dedicated to food, communication, duration
	Homeostasis	Hunger, thirst, temperature, physical activity

Each application case (food category, brand, market, target group, concept and product being developed) is specific and this specificity has to be cross-analyzed with the specificity of the consumers of interest. Contextual categories and subcategories listed in [Table 5.1](#) should be considered to design protocols for consumer studies. For each subcategory, the questions are: Is it of interest to compare different situations in this category? If yes, which situations should be considered in the protocol (two or three conditions)? Or are slight differences acceptable although they might have an impact on hedonic responses and be part of the unexplained variance?

In other words, when variability within a contextual category is expected to be high, there are two methodological options:

1. to test products under natural conditions and keep the variability as part of the “noise”, the natural variance of responses;
2. to control, to select restricted conditions by making a selection from all possible ones (i.e., split the protocol into contrasting situations and obtain the adequate number of subjects for each relevant situation), for example, to conduct a test in a workplace canteen and collect liking of coffee when served in ceramic or cardboard cups.

Decisions on which option to follow for each contextual factor are made on scientific and operational knowledge and depend on the objective of the study.

Another crucial point is the data to be collected. Participating in a study represents a bias in itself compared to a natural situation. Thus, questionnaires have to be as short as possible so that consumers will not be affected by a long series of questions. For this reason, observational approaches are often followed in living labs: video recording, choice between options, weight of served/consumed quantities.

3. MAKE A LABORATORY BE A REAL-LIFE SITUATION (A LIVING LAB)

The principle of a living lab is to collect consumer data in a real environment. To do so, technological equipment is used to record relevant data from users who have agreed to be observed. Let us consider the case of *Le Restaurant*, a living lab (ENOLL) at the Institut Paul Bocuse (France).

Opened in 2008, *Le Restaurant*—the experimental platform of the Institut Paul Bocuse—is a research and innovation structure developed by a team of scientists and professionals in the fields of culinary arts, food service, and hospitality. The platform has now reached its maturity as a living lab, labeled ENOLL, the European Network of Living Labs, and serves for scientific research and applied studies. The living lab provides a unique setting allowing testing in actual eating situations. It is a fully modular experimental laboratory. It includes a restaurant and a kitchen with high-tech equipment, including high-yield preparation materials and audiovisual recording devices. The living lab is designed

to replicate actual cooking and consumption situations. Both the floor and the ceiling of the restaurant and the kitchen are modular to adapt to different equipment configurations, allowing for the construction of different contexts. Thanks to the availability of food service professionals, it is easy to create every type of restaurant environment (traditional, collective, brewery, cafeteria, etc.) as well as changing the kitchen configuration for specific needs. This includes changes in the ambience with adjustable temperature, sound system, visual environment, lighting, air quality, furniture, and so on. To ensure fully natural conditions, measurement methods partially include subject-involving procedures (such as questionnaires) and give privilege to those based rather on observation, so the customers do not feel like subjects in an experiment. Examples of settings in the living lab are presented in Fig. 5.1.

Studies are conducted with the regular clientele of Le Restaurant or, if needed, a targeted population is recruited (e.g., children, elderly) and the design is defined accordingly. Users are key components of each study, which is a very specific dimension of our living lab in the field of food sciences and innovation. Depending on the specific technique used, they are involved as actors in real-life situations—captured through in situ methods, or as collaborators—when expertise is needed and explicated. Consenting users are not necessarily aware of the whole range of issues of the study; discrete data acquisition material and



FIGURE 5.1 Examples of settings in the living lab of the Institut Paul Bocuse. (a) Cafeteria, (b) high school, (c) brasserie, (d) fine dining restaurant.

an adequate contextual setting provide a strong sense of a real-life situation to the users. This is particularly true for the experimental restaurant when it is used during the daily opening (commercial restaurant) period. Among the preferred techniques are ethnographic studies through video, experimental economics (design of incentive-compatible mechanisms aimed at eliciting economic value in contextualized situations), and interviews and short questionnaires for sensory and hedonic evaluation (with the help of tablet equipment).

The living lab allows researchers to evaluate the dynamics of food consumption and the liking of food at different moments in the meals, taking into account and providing information on the kinetics of consumption (Allirot et al., 2014; Clicerì, Petit, Garrel, Monteleone, & Giboreau, 2017; Fernandez, Bensafi, Rouby, & Giboreau, 2013).

For instance, a study dedicated to bread consumption compared preference before and after a meal in relation to choice during the meal (Iborra-Bernad, Wathelet, & Giboreau, 2012). Two breads, a white bread and a whole wheat bread, were first evaluated in a controlled environment and then offered during a regular lunch. Volunteer customers of the restaurant participated ($n=117$). The video analysis confirmed a large majority (80%) of consumers chose first their preferred bread, in coherence with their declared liking before the meal. However, thanks to the following of consumption over the course of the meal and the evaluation of the consumers' judgment at the end of the meal, the results showed a significant decrease in preference for the whole wheat bread (from 48% to 31%, $P \leq .05$) together with a decrease in consumption. This illustrates that declarative liking and actual consumption are not always correlated and emphasizes the value of conducting multiple-level approaches and real-life situation studies.

In summary, a living lab is a powerful tool to study users' choice and preference in real-life situations. An experimental restaurant operated by professionals coupled with scientific protocols allows researchers to keep good control over several contextual factors, such as the physical (atmospherics, table art, portions, staff, food offerings) and some social (staff, information) factors, together with the integration of consumers' variability, including cultural, psychological, and physiological contextual factors.

4. MAKE A REAL-LIFE SITUATION BE A LABORATORY

In some cases, it is preferable to obtain consumer results in a free-living situation, i.e., a situation in which the contextual factors are not at all managed by the experimenters and allowed to be as they naturally are. This is particularly true in public health-oriented projects for which the objective is to evaluate the impact of an intervention (e.g., at school, Morizet, Depezay, Combris, Picard, & Giboreau, 2012; in nursing homes, Pouyet, Benattar, Cuvelier, & Giboreau, 2015; Pouyet, Cuvelier, Benattar, & Giboreau, 2015; at the hospital, Navarro et al., 2015). Examples of settings of field experiments are presented in Fig. 5.2.



FIGURE 5.2 Examples of field experiments. (a) School cafeteria, (b) nursing home.

The principle of evaluating consumers in real-life settings is to select one principal variable and make sure this variable is collected as precisely as possible. Food intake is very often the variable of interest. In that case, weighing the food remaining on plates is the best measure. To do so, several steps are needed to guarantee the recorded data are as accurate as possible and linked to the identification of individuals.

A study was conducted in a school cafeteria following a real-life experimental procedure. The objective of this study was to evaluate food waste in relation to food liking (Baldridge, Morizet, Hanicotte, Giboreau, & Schwartz, 2012). The consumption and the liking of dishes were measured over 5 days in a primary school (students 8–11 years of age). Served quantities were standardized. Pictures of individual trays were taken at the clearing point. A total of 776 pictures of trays were analyzed showing that the most wasted food was vegetable dishes, and more specifically the cooked vegetables served cold as a starter. In parallel, 248 interviews of children were conducted and allowed the measure of the liking of each food. The Pearson coefficient relating waste to liking was highly significant ($r = -0.997$, $P < .0001$). This study confirmed the prominent role of liking in food consumption in children and led to the selection of the least-liked food to be reworked from a culinary and sensory point of view.

In summary, collecting consumer data in real-life settings is a valuable option complementing lab and living lab approaches and is particularly useful when the specificity of the studied context does not allow one to recruit consumers for a lab test or to reproduce an ecological environment. In such cases, the lab has to go to the field.

5. CONCLUSION

The study of the context effect on consumers concerns many disciplines and is a fascinating area for researchers. It is also a wide open field for innovation as interactions between product and context offer multiple combinations. Finally,

it is also a challenge for consumer scientists to design in situ relevant fieldwork conditions, and real-life settings may become the most common approaches for product testing.

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Part II

Health-Related Issues

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Chapter 6

Measuring Appetite and Food Intake

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Scientists interested in human eating and drinking need reliable measures of ingestive behavior. Historically, two measures have been widely used: estimates of how much people consume (intake measures) and estimates of each individual's momentary desire to eat (appetite ratings). Studies using these measures have contributed to many aspects of our understanding of human appetite: why some people are prone to overconsume, how beliefs and expectations alter how much we eat, the relative importance of palatability and energy density on meal size, how variations in the sensory characteristics of food alter eating rate, etc. Although technological advances are constantly adding to the experimental approaches available to researchers with interests in eating behavior, food choice, and appetite, measures of intake and self-reported appetite still predominate. The aim of the first part of this chapter is to explore intake and rated appetite measures as research tools, focusing on the key experimental design issues that each study needs to consider. The chapter then briefly describes more detailed (microstructural) approaches, before discussing the interrelationship between these measures, and how studies that combine measures have provided the clearest insights into human ingestion.

1. MEASURING FOOD INTAKE

For anyone interested in human ingestion, ultimately an accurate measure of how much food has been consumed in an eating episode (e.g., a meal or snack) can offer important clues about the causative mechanisms underlying eating behavior. Intake measures have been used extensively in both laboratory and naturalistic settings ever since scientists became interested in human ingestive behaviors. The typical laboratory-based study involves provision of test foods to volunteers who then consume these under highly controlled conditions: in contrast, naturalistic studies tend to use diary self-report measures to estimate intake.

A key issue to consider at the outset is, how representative of real behavior are highly controlled intake tests of humans eating under laboratory conditions? This remains a vexing question, and one that has been widely discussed (Gibbons, Finlayson, Dalton, Caudwell, & Blundell, 2014; Meiselman, 1992a, 1992b; Obarzanek & Levitsky, 1985; Stubbs, Johnstone, O'reilly, & Poppitt, 1998). Clearly many features of eating studies in a laboratory environment lack "ecological validity": participants eat in a barren environment, often by themselves (unless social influences are of interest), and in most cases with limited choice over what and when to eat. However, these very limitations give the level of experimental control needed to elucidate the complex factors controlling human behavior. In contrast, data recorded from real consumers under real conditions might be expected to be more representative. Yet, relying on self-report data, as most studies in naturalistic settings have to, raises issues of compliance, accuracy and lack of control. Both sets of studies need, therefore, to be considered with some caution, but arguably the best approach for studies aimed

at elucidating mechanisms is to test ideas under controlled laboratory conditions first and then use longer-term diary studies to further check the validity of the laboratory findings (Gibbons et al., 2014). Thus the most effective research programs need to include aspects of both approaches. There are also some situations in which the question can be tested only with “big data,” that is, studies with large representative population samples, and these have to use estimates of intake from sampling large numbers, because laboratory studies would be expensive and impractical.

1.1 Measuring Food Intake: Laboratory Approaches

In principle, the measurement of food intake in laboratory studies of eating should be simple: in most studies, a served portion of food is weighed before and after an eating episode and the difference in weight is taken as a measure of overall intake. The majority of experimental research on appetite has used this approach. The resulting information on how different manipulations can lead to enhanced or reduced intake in a defined meal has provided important clues about both the mechanisms controlling eating in different situations and the potential development of treatments for over- and undereating.

When setting up a defined intake test, there are a large number of variables that can be manipulated that can modify an apparently simplistic piece of data (weighed intake) into a sensitive experimental tool. Key decisions in study design include:

- how much food to serve
- what food to serve
- when the test meal is to be served
- how much time between eating events and whether this is controlled in the design
- to what extent the participant will be aware that his or her intake is being measured
- whether intake will be summarized as the mass or the energy consumed
- whether intake data will be further broken down into macronutrient intakes
- what other eating-related measures are needed to interpret these data in relation to the study hypotheses

The following sections consider each of these issues in turn.

1.1.1 How Much Food to Serve?

When considering how much food to serve in an intake test, two features of human eating behavior need to be considered. The first is the portion-size effect: the reliable observation that the amount consumed at a meal increases as the amount served is increased (Fisher & Kral, 2008; Fisher, Liu, Birch, & Rolls, 2007; Levitsky & Youn, 2004; Rolls, Morris, & Roe, 2002, 2004; Zlatevska, Dubelaar, & Holden, 2014). Serving size is a critical short-term determinant of how much people consume.

Arguably, this effect was demonstrated most clearly, if somewhat bizarrely, in the now infamous bottomless bowl of soup study (Wansink, Painter, & North, 2005). In that study, participants ate soup from a bowl while, unbeknownst to them, additional soup was either pumped surreptitiously into or removed from the bowl while they ate. Those whose bowls were automatically refilled ate 73% more soup than those whose serving was not manipulated during ingestion (Wansink et al., 2005). The portion-size effect has important implications for intake tests: serve people more and they will consume more, questioning the validity of the intake measure as representative of what the participant might normally do.

In terms of measuring intake, the second problematic feature of human eating is the learned habit of emptying your plate: for example, when asked whether people ate all of the food on their plate at their last meal, 91% of respondents reported eating the complete serving, and for 92% of those this was a planned action, that is they knew they were going to eat all of their meal before they started (Fay et al., 2011). The implication is that intake studies that serve smaller portions may lead to habitual plate-clearing. This is problematic because it greatly reduces the chance of detecting differences in intake between test conditions. For example, consider a study testing the hypothesis that restructuring a food can generate the belief that one version would be more filling (i.e., enhancing expected satiety; see Chapter 7 by Forde). If the served portion in the test was too small, participants may eat all the food in both the normal and the putative enhanced-satiety condition. This could lead to a classical Type 2 statistical error: the analysis may show no difference in intake purely because the design lacked the sensitivity needed to detect the difference in intake; there was a ceiling effect generated by portion size. In contrast, serving a very large portion that could not be completed will force individuals to choose to terminate their meal without finishing the portion, thus preventing ceiling effects in intake. But now the study runs the risk of overconsumption relative to what people would consume normally because of the portion-size effect noted earlier.

There is no simple single solution to the conflicting problems of plate clearing versus portion-size-enhanced intake, but these issues are important to bear in mind when considering the validity of intake measures. One possible way of reducing both limitations is to serve a representative portion (i.e., one that may be close to the habitual portion) but to replace the first serving with a new portion before the first serving has been eaten in full. In this way the participant is not given the visual cues of a larger portion that may promote overconsumption, but likewise never has the opportunity to make a decision to end their meal based on an empty plate. This approach is unlikely to fully solve the plate clearing versus portion size issue, but in principle should at least limit the impact of both these extremes. However, this approach is hard to implement if the intake measure is based purely on weighing intake before and after serving: this is easiest to achieve by constantly monitoring the amount consumed using some variation of the universal eating monitor (UEM; Kissileff, Kilngsberg, & van Italie, 1980), described in more detail later in the chapter.

1.1.2 *What Food to Serve?*

An important advantage of laboratory-based intake tests is that they allow the experimenter absolute control over the food being consumed, and so factors like energy density, macronutrient content, sensory quality, etc., can all be designed to meet the experimental needs of the study. For example, studies that consider whether intake within a meal is regulated by the energy content of food can contrast intake of matched high- and low-energy-dense versions and see whether the energy manipulation reduces acute intake. Studies of this kind have generally found that people tend to regulate the mass (or volume) they consume rather than energy intake (Bell & Rolls, 2001; Ello-Martin, Ledikwe, & Rolls, 2005; Viskaal-van Dongen, de Graaf, Siebelink, & Kok, 2009; Yeomans, Gould, Leitch, & Mobini, 2009), an observation leading to suggestions that increased energy density leads to passive overconsumption (Blundell & Macdiarmid, 1997; Viskaal-van Dongen et al., 2009), increased overall energy intake without increasing actual mass consumed. Likewise, maintaining the same nutrient content but adjusting the sensory characteristics of the ingested food can test ideas about the impact of factors such as the role of palatability (Yeomans, Blundell, & Lesham, 2004) or specific theories about oral processing (de Graaf, 2012; de Graaf & Kok, 2010; Hogenkamp & Schioth, 2013). With palatability, even subtle changes in sensory characteristics can greatly alter how much is consumed (Yeomans, 1996), and the effects of altered liking on short-term intake are both robust and predictable (Yeomans et al., 2004), with intake increasing as a linear function of liking. Oral processing time is also a critical influence on satiation and satiety: foods that require greater mastication or which have thicker texture tend to be more filling (Forde, van Kuijk, Thaler, de Graaf, & Martin, 2013; Mattes & Considine, 2013; Zijlstra, de Wijk, Mars, Stafleu, & de Graaf, 2009; Zijlstra, Mars, et al., 2009). Thus, when contrasting intake of different foods, even subtle differences in texture and liking generated as an indirect consequence of modifying overall energy content, for example, can have a great impact on observer behavior and so inadvertently influence the outcome of studies. These two examples show how considerable care has to go into the choice of test foods relative to the specific hypotheses under test, even for meals with relatively simple foods.

What style of meal (breakfast, lunch, buffet, snack, etc.) is then most appropriate for an intake test? The answer depends on the study aims. If the researcher is interested in the effects of a manipulation (e.g., to the food or the eating environment) on food selection, then serving a variety of foods representative of multiple food classes (for example, including a variety of savory and sweet items) and varying in core macronutrients, often referred to as a buffet meal test, may be the best choice. For example, if researchers wanted to examine the extent to which manipulating the macronutrient content of one meal (the preload: see Chapter 7 by Forde for a full discussion of preload methodology) alters macronutrient selection at a second meal, a buffet meal that includes the element of food choice is required to answer this question, and historically many studies

have adopted this approach (Griffioen-Roose, Mars, Finlayson, Blundell, & de Graaf, 2009; Hall, Millward, Long, & Morgan, 2003; Rodin, 1990). Here the research question explicitly requires that the participant has the opportunity to vary the nutritional content of his or her selected meal. However, buffet meals are not representative of habitual eating, and these types of meals tend to be reserved for celebrations and social events, at least in Western society. Intake at a buffet meal is likely to be enhanced by social facilitation (Herman, 2015; Hetherington, Anderson, Norton, & Newson, 2006; Levitsky & Youn, 2004), uncontrolled portion size (Rodrigues, da Costa Proença, Calvo, & Fiates, 2012; Wansink & Van Ittersum, 2013), and the effects of variety (Brondel et al., 2009; Levitsky, Iyer, & Pacanowski, 2012; Raynor & Epstein, 2001; Rolls, Rowe, et al., 1981). Consumption at a buffet is also heavily dependent on how much an individual chooses to serve him- or herself (Brunstrom, 2011; Fay et al., 2011), and so the measure of intake may reflect more decisions made at the point of serving rather than once actual ingestion has started. The buffet meal also limits the ability of the researcher to measure other aspects of eating, including the microstructural components of eating discussed later.

The alternative to serving a buffet with a variety of foods is to use a simpler meal, in which the lack of choice means the experimenter can control all aspects of what is ingested. For example, if the experimenter is interested in eating rate, then the meal has to be fairly homogeneous to ensure that each mouthful has similar sensory and nutrient characteristics. For this reason, large numbers of studies have used complete meals such as pasta served in a sauce (Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Gray, French, Robinson, & Yeomans, 2003; Masic & Yeomans, 2014a; Robinson, Gray, Yeomans, & French, 2005) or savory rice dishes (Griffioen-Roose et al., 2009; Griffioen-Roose, Hogenkamp, Mars, Finlayson, & de Graaf, 2012; Zandian, Ioakimidis, Bergh, Brodin, Sodersten, 2009). These types of meal fit well with cuisine: these are meals that consumers would recognize as an appropriate food to eat as a course of a meal. However, they provide only a single course, and further information on eating can be obtained by adding a second (for example, dessert) course (Brondel et al., 2009; Caton, Bate, & Hetherington, 2007; Yeomans & Chambers, 2011). This allows questions such as how manipulations alter either the time taken to eat or the quantity of the first course consumed, before the switch to a dessert course. It also allows tests of how manipulation of the characteristics of the first course modulates intake at the second, for example, in the context of sensory-specific satiety (Brondel et al., 2009). But no intake test is perfect, and each study has to choose which of the limitations are likely to have the least negative impact on the study outcome.

1.1.3 When Is the Test Meal to Be Served, and to What Extent Should Prior Intake Be Controlled?

The timing of intake tests is also critical, in terms of both the test meal itself and the extent to which intake prior to the test meal was controlled. Studies examining the effects of manipulating the content of one meal on intake at a subsequent

test meal, classically the preload test, are usually interpreted in terms of satiety and are discussed at length elsewhere in this book (Chapter 7). Here the discussion is limited to decisions about the actual timing of intake tests per se, rather than the preload design in detail. Unlike many areas of research in which the timing of tests can be fitted around the convenience of the experimenter, appetite researchers have to work during traditional meal breaks! Indeed, in some cases the time at which a participant chooses to eat can become a useful measure in its own right. For example, in a neat study looking at the relationship between changes in the circulating levels of the gut hormone ghrelin and spontaneous food intake (Cummings, Frayo, Marmonier, Aubert, & Chapelot, 2004), participants were served a standard breakfast in the laboratory, and remained in the test area until 2200 h. They were deprived of all external time cues and exposed to artificial light only, so that they could not use external cues to predict the timing of meals. After being served an ad libitum lunch at midday, they were instructed to request their next meal when they felt appropriately hungry, and again the test dinner was an ad libitum meal. Note here the experimenter assessed not only intake, but also the time between meals, defined as the intermeal interval. In this case these data are critical to the study question: to what extent are spontaneous increases in hunger associated with a rise in circulating ghrelin levels? The study serves to illustrate the potential value of knowing not only the size of a test meal, but also the decision to initiate a spontaneous meal in relation to the influence of a putative hunger signal, the hormone ghrelin.

In practice, few laboratories have the facility to test participants in exclusion from external time cues, and the ubiquity of time cues in modern electronic devices makes time-blinded studies increasingly difficult to run. Nevertheless, knowing that such cues are important predictors of eating does mean that experimenters have to design studies so that test meals are timed to broadly reflect habitual eating practices. Serving a test lunch at 11:00 a.m. because this is convenient to the experimenter is very unlikely to result in useful data on realistic human eating! Likewise, testing intake at breakfast served between 8:00 and 9:00 a.m. in a laboratory is unrepresentative of normal behavior if the test participants normally eat breakfast earlier or later than that or even are habitual breakfast skippers. Thus, meal times have to be chosen to match as closely as possible the habitual behaviors of the test participants, and likewise, screening of participants to exclude those for whom the meal would not approximate their normal habits increases test validity.

1.1.4 The Influence of Participant Awareness

Ethically (and practically) it would be impossible to give participants an intake test without them knowing. This raises critical questions about experimental design and data interpretation that need to be taken into account when finalizing study designs. If participants are aware their intake is being monitored, this knowledge might alter their behavior. It could also be predicted that different groups of participants might react to that knowledge differently: for example,

it is plausible that participants with a history of restrained eating might eat less if they know their intake is being measured as a demand-lead response, whereas unrestrained eaters would be predicted to be less affected by knowing intake was being measured. Similar arguments could be used for participants divided by weight class or history of disordered eating. Distracting participants from the intake measures could be one approach to mitigate demand effects, but there is now a growing literature showing that people consume more when distracted (Brunstrom & Mitchell, 2006; Higgs & Woodward, 2009; Ogden, Oikonomou, & Alemany, 2017; Oldham-Cooper, Hardman, Nicoll, Rogers, & Brunstrom, 2011; Robinson et al., 2013). In contrast, explicitly asking people to pay attention to food whilst eating has been shown to increase memory for what was consumed and reduce subsequent intake (Higgs & Donohoe, 2011). These converse effects of distraction-induced overconsumption and attention-driven enhanced memory have important implications for the design of intake studies: using distraction to reduce attention to food could reduce demand effects but lead to increased intake, whereas drawing attention to eating could lead to demand-driven reduced intake by conscientious participants. These issues have not been widely discussed in the appetite literature, but could have affected the outcome of numerous studies.

How then to mitigate the potential negative effects of demand? Different strategies can be employed depending on whether the intake test uses repeated measures (i.e., the participant consumes the same test meal under different conditions, determined by the study design, over a number of days) or contrasts behavior between groups in a single intake test. Demand effects are much easier to control for in repeated-measures designs. In our laboratory, when we have measured intake of the same meal over a number of days, the typical finding is that people take longer to eat and consume slightly less on the first day than on the subsequent 2–4 days. The initial response can be explained by wariness about eating in an unfamiliar environment: participants are noticeably more relaxed on subsequent days, although when the same meal is used at each session, intake tends to decline from a peak on day 2, probably as a consequence of overfamiliarity with the food. The optimal testing regime for within-participant intake tests therefore involves a familiarization day as the first test, and then a maximum of six (but ideally no more than four) actual test sessions, spaced several days apart. It is also critical to counterbalance the order of conditions across the test days and to test for order effects in the data analysis. If these rules are adhered to, study power is increased and the effects of demand are limited (but not removed).

A second important design feature that can mitigate demand effects on intake measures is the use of a cover story that directs the attention of the participant away from the hypothesis under test. A common strategy is to include measures of mood (including ratings of appetite: see later) before, during and after the meal and then inform the participant that the study examines how mood interacts with eating. This approach meets the ethical requirements of

informed consent (participants are aware their mood and eating will be measured) but does not make explicit the variations between test days that test the key hypotheses.

Finally, the use of a posttest measure of the extent to which participants became aware of the test hypothesis can be used to statistically test for demand effects: either by excluding those participants who had “worked out” what the study was testing (a valid approach when there are few aware participants) or by including awareness as a factor in the analysis.

Despite these practical approaches to mitigating the effects of demand on intake measures, these issues remain important and are particularly evident in between-participant tests. The usual approach to this issue in the restraint literature (Herman & Mack, 1975), originating in the classic studies on externality by Schachter and colleagues (Goldman, Jaffa, & Schachter, 1968; Schachter, Goldman, & Gordon, 1968; Schachter & Gross, 1968), is to present the actual intake test as a “taste test,” in which participants are provided with multiple samples of food to “taste” with the apparently informal instruction that they are welcome to consume as much as they like since any waste has to be disposed of. The classic finding is that restrained eaters consume less than unrestrained eaters under normal conditions (Herman & Mack, 1975): thus the demand effects lead them to “stick to their diet.” The key finding that this self-control can be broken by a number of disinhibitors (Herman & Polivy, 1984) provides evidence of the sensitivity of the disguised snack intake test as a valuable way of manipulating demand. But once the effects of distraction and attention are included, interpretation of these data becomes ever more complicated.

Overall, demand effects are a clear problem for laboratory-based intake tests, and experimenters need to pay close attention to these issues when designing studies that test their hypotheses free from confounding demand effects.

1.1.5 How Best to Analyze Laboratory-Based Intake Measures?

A complete discussion of statistical measures used to analyze intake data is beyond the scope of this chapter, and for the majority of studies some variation on the analysis of variance, probably including key covariates, remains the most common and appropriate statistical tool. The focus of this section is more a discussion of what aspects of intake data need to be analyzed and why.

There exists some tension in overall reporting of intake data between measures of mass (typically weight consumed in grams) and measures of energy intake (mass intake converted into an estimate of energy intake, usually based on Atwater values). Some studies report energy alone, some mass, and some both, with studies from a nutritional perspective tending to report energy and those taking a more behavioral approach reporting mass consumed. Although both types of data have merits in relation to different experimental hypotheses, intake measures summarized as energy intake alone need to be viewed with some caution.

Second, the method of estimating energy intake depends on the accuracy of the Atwater calculations: there is increasing evidence that these estimates may be less accurate than is widely believed. For example, Atwater calculations have been shown to significantly overestimate the actual metabolizable energy in nuts like almonds (Novotny, Gebauer, & Baer, 2012) and walnuts (Baer, Gebauer, & Novotny, 2016), probably because the physical structure of these nuts limits the bioavailability of the fats that provide most potential metabolizable energy (Grundy et al., 2016; Morgan, Strauch, & Blume, 1930). Neither of these concerns renders estimates of energy intake invalid, but they do suggest that analyzing estimated energy intake without also reporting mass consumed has the potential to be misleading. In practice, for studies that serve only a single food the outcome of analyzing mass and energy will be the same, as the latter is a simple mathematical transformation of the former. However, where buffet meals are used, both factors are needed to interpret behavior.

It is also a common approach to summarize intake at a buffet meal in terms of intake of various macronutrients. This approach again has merits in some situations, but also has to be used with some caution. Consider the following example (based on an unpublished study). The researchers were interested in how varying protein content at breakfast modified food selection at lunch: taken at face value, the participants consumed the same amount of energy at breakfast, either as a protein- or as a carbohydrate-rich meal. They then had a choice of foods to select from at lunch. One way of summarizing the study is in terms of macronutrient intakes, and the study appeared to show less protein consumed after the high-protein breakfast. However, now consider the actual test foods used: the high-protein breakfast included eggs and ham, the high-carbohydrate meal was based on bread and cereal. Cold meats, eggs, and cheese were among the buffet options. Analysis of changes in intake showed that those in the high-protein condition specifically ate less meat and eggs at the following lunch. So is this evidence of protein-specific satiety or, more plausibly, that participants who recall eating ham and eggs for breakfast eat less ham and eggs at lunch?! This cautionary tale shows the importance of (1) looking closely at data and (2) ensuring that test manipulations are covert to minimize demand effects.

1.1.6 Summary

The previous sections should allow researchers to develop intake tests that are optimized around their research question. It is unlikely that all the pitfalls of experimental design have been identified: the nature of science is that we continue to learn more about behavior and how it needs to be measured. Yet the breadth of published research on human ingestion has allowed some consensus on how best to measure intake under laboratory conditions.

1.2 Measuring Long-Term Food Intake

While studies of acute food intake offer maximal experimental control, they allow only a very short-term assessment of the effects of different influences on

human eating. To get more detailed insights into longer-term influences, measurements need to extend over days or weeks. The ultimate test would be to measure every item an individual eats in a free-living environment over an extended period of time. In practice this is nearly impossible to achieve accurately.

There are two widely used techniques to evaluate intake in epidemiological studies: diet diaries and food frequency questionnaires (FFQs). Diet diary approaches range from weighed food records, whereby the participant is provided with a portable balance and records the weight of everything he or she then eats or drinks, to recall of intake over a set period (usually 24h). A full review of these techniques is beyond the scope of this chapter, but has been covered elsewhere (Willett, 2012; Yang et al., 2010). Here the key focus is on the validity and accuracy of these approaches.

Note that diet diaries and FFQs were designed with different research aims in mind. FFQs are more aimed at establishing population estimates of intakes of specific nutrients or diet groups, such as intake of fruit and vegetables. Because this chapter is aimed at estimating overall food intake, the focus here is only on the extent to which food frequency measures can give an approximation of actual overall food intake rather than the relative nutrient/food content within the diet. In contrast, diet diaries should be able to better estimate actual intake, and that has been their primary use.

So how useful have long-term self-report estimates of intake been in elucidating appetite? Diary-based studies have been used effectively to assess a wide range of influences on habitual human ingestive behavior. Thus, diary records have substantiated a number of findings from laboratory-based studies. For example, the well-established observation that people eat more when in a group than alone in the laboratory (e.g., Clendenen, Herman, & Polivy, 1994; Cruwys, Bevelander, & Hermans, 2015; Higgs, 2015; Pliner, Bell, Hirsch, & Kinchla, 2006; Redd & de Castro, 1992) is backed up by similar findings in analyses of food diaries (de Castro, 1990; de Castro et al., 1990). Likewise, the impact of food palatability on short-term intake in the laboratory is well known and robust (see Yeomans et al., 2004, for review), and even though people habitually avoid less palatable food, the influence of palatability is still evident in diary data (de Castro, Bellisle, & Dalix, 2000; de Castro, Bellisle, Dalix, & Pearcey, 2000). FFQ measures have also been invaluable in gauging population compliance (or usually lack of compliance) with dietary guidelines, while also allowing, among many other things, the investigation of large population differences between obese and normal-weight individuals (e.g., Fung et al., 2001; Gittelsohn et al., 1998; Rosenheck, 2008) and testing of factors both predicting and promoting food and vegetable intake in children (Boynton-Jarrett et al., 2003; Galloway, Lee, & Birch, 2003; Haire-Joshu et al., 2008; Klepp et al., 2005; Ma, Betts, Horacek, Georgiou, & White, 2003).

Estimates of long-term intake have a number of shortcomings, however (Bingham et al., 1994; Biro, Hulshof, Ovesen, & Cruz, 2002; de Castro, 2000; Schoeller, 1995), and these warrant further discussion here.

1.2.1 *High Error Rates in Data Collection*

Some of the high error rates from diary studies are due to underreporting of actual consumption, either through forgetting or as a consequence of the desire of the participant to paint a positive picture of his or her behavior (a demand effect). If these errors were similar across all groups then they would not necessarily influence the study outcome: if everyone underreported intake by 10% then actual intake could be estimated to approximate actual consumption. The real issue is when different groups use diaries in different ways, with the classic example being selective underreporting by obese patients (Goris, Westerterp-Plantenga, & Westerterp, 2000; Johansson, Wikman, Åhrén, Hallmans, & Johansson, 2001; Lansky & Brownell, 1982; Poppitt, Swann, Black, & Prentice, 1998; Voss, Kroke, Klipstein-Grobusch, & Boeing, 1997).

1.2.2 *Unmeasured Variables Affect Behavior*

Just as laboratory studies exert control that is unrepresentative of real-life behavior, the very nature of naturalistic data collection is that there is no control on other factors. Detailed epidemiological studies try to collect large amounts of background demographic data: socioeconomic status, gender, age, etc. However, there is always a chance that differences in behavior between population groups may reflect a variable that has not been identified in the study design.

1.2.3 *Are These Really Naturalistic Data?*

Although diary studies are often interpreted as reflecting real-world data, the mere act of having to record all behavior can cause subtle changes in behavior that make the final record unrepresentative. Examples might be people deliberately increasing their intake of foods they consider to be healthier or reducing intake of specific components of their diet that they think may be perceived as less healthy to increase the impression of what they consider to be a more positive account of their behavior. This is equally true for food frequency measures, where again it is socially desirable to underplay intake of foods seen as less healthy and exaggerate intake of healthy foods like fruit and vegetables. Such demand effects are hard to fully control for and greatly complicate between-group comparisons, although they are less of an issue where data are used to test a manipulation in a crossover design, whereby selective misreporting should be seen in all phases of the study.

While these issues will leave doubts about the accuracy of long-term intake measures, methodological improvements have to some extent limited the impact of these key concerns.

1.3 Which Approach is the Best?

There are clear advantages and disadvantages to the different approaches to long-term intake measurement. FFQs are cheap and easy to administer and so allow

rapid sampling of large populations, diet recall requires greater staff involvement to lead the recall and so get the most accurate data, while weighed diaries are even more time-consuming for both participant and researcher, yet would be predicted to give the most accurate data (within the limitations noted above). Although all of these approaches have their limitations, many see the weighed food records approach as the “imperfect gold standard” (Boushey, Coulston, Rock, & Monsen, 2001) for long-term intake measures. But how similar are data from these different approaches? Some studies have made direct contrasts between measures within the same population group as a direct test of the effectiveness of low-cost long-term measures. A good example compared intake estimates using an online FFQ (Food4Me; Forster et al., 2014; Markovina et al., 2015) with 4-day weighed intakes for the same participants (Fallaize et al., 2014). Notably, there were no significant differences in estimated daily energy intake between the two methodologies, showing how improvements in the design of FFQs and the way these data are analyzed have greatly increased the accuracy of these measures.

1.4 Optimal Design of Studies Exploring Naturalistic Intake

The concerns noted previously cannot all be addressed in the design of diary-based studies, but knowledge of these limitations can inform better study design and appropriate caution in data interpretation. As with weighed-intake studies, those undertaking diary-based investigations have a number of critical decisions to make at the outset:

- how to promote compliance
- how to assess portion size

1.4.1 Promoting Compliance and Accuracy

The increased recognition of underreporting as a genuine concern in diary-based studies led to a number of attempts to promote compliance. One approach was to ask participants to photograph everything that they consumed (Foster et al., 2006; Robson & Livingstone, 2000; Subar et al., 2010) and then to use these photographic records to confirm the accuracy of written reports. This approach has been shown to increase consistency of reporting (de Castro, 2000; Subar et al., 2010), although it cannot prevent underreporting (both the diary entry and the photograph have to be recorded by the participant, who could simply forget, or choose not to report, some items). Similarly, to improve accuracy of recall in dietary recall methods, such as the US Department of Agriculture’s Automated Multiple-Pass Method (Blanton, Moshfegh, Baer, & Kretsch, 2006; Moshfegh et al., 2008), recall is guided through a series of stages, which help prompt accuracy and completeness (Fig. 6.1). The careful use of such measures has been shown to greatly increase the accuracy of intake measures from recollection (Blanton et al., 2006; Conway, Ingwersen, & Moshfegh, 2004; Conway, Ingwersen, Vinyard, & Moshfegh, 2003).

Step	Procedure
Quick list	The participant freely recalls all of the food and beverage items he or she has have consumed over the preceding 24-h period without interruption from the researcher
Forgotten foods	The researcher cues recall of nine frequently forgotten food categories that include nonalcoholic and alcoholic beverages, fruit, cheeses, and bread items
Time and occasion	The reported food and beverage items are reviewed and each item is assigned to an eating occasion (e.g., breakfast and snack)
Detail and review	Detailed information is gathered about brand names, recipes, portion size, added items (including condiments and fats), source (homemade or prepackaged), and location of consumption
Final probe	The participant reviews the information and is given the chance to recall any foods he or she may have missed, or report any small items of food he or she may not have felt was worth reporting. Finally, he or she assesses whether the reported food intake was more than, less than, or typical of his or her habitual intake

FIGURE 6.1 The five stages respondents are led through to maximize recall accuracy in the Automated Multiple-Pass Method for 24-h dietary recall.

1.4.2 Increasing Estimated Portion Size Accuracy

Portion size estimates are also complex. Simple food diaries traditionally had entries like “cheese and tomato sandwich.” However, small differences in individual preferences and habits (for example, with a cheese sandwich, whether a spread was used as well, the type and quantity of cheese, etc.) all have an impact on nutrient intake. A simple written record can provide only a broad approximation based on averages for that food item. FFQs vary in how portion size is dealt with: the weakest versions make no reference to portion size, others provide portion sizes predefined in the questionnaire, while others allow the participant to self-report portion size. But it is well established that participants have difficulty in estimating portion sizes (Cade, Thompson, Burley, & Warm, 2002; Faggiano et al., 1992), and failing to address this can lead to poor intake estimates using the FFQ. Online versions of FFQs allow pictures to be displayed to allow self-selection of portion sizes, which facilitates accuracy (Forster et al., 2014). Improved accuracy in portion size estimation has led to the largest improvements in intake measurements using FFQ methodology.

1.5 Intake Measures in Summary

In summary, the decision on which approach is best to assess intake is entirely guided by the research question: for rigorous testing of specific hypotheses, the preference remains to measure appetite and eating behavior under the

strict, controlled conditions achievable only in the laboratory. But this limits sample sizes, and often leads to studies in very selected populations, reducing the representative nature of the outcome. Advances in the accuracy of long-term measures will pave the way in the future for wider testing of the types of hypotheses usually restricted to laboratory studies in free-living representative study populations.

2. ASSESSING SUBJECTIVE APPETITE

Experimental studies that explore the relationship between appetite and eating in humans make widespread use of our ability to introspect, and so give some expression of our current conscious awareness of our motivational state through the use of appetite ratings. The earliest studies tended to use categorical, or Likert, scales, with discrete numbers representing different levels of the relevant experience (Fig. 6.2(a)). These scales have largely been replaced by visual analogue, or line, scales (VAS; Fig. 6.2(b)), whereby experience is rated on a continuous dimension between two extreme possibilities. A more recent approach (the affective generalized labeled magnitude scale, AgLMS; Fig. 6.2(c)), developed from the generalized labeled magnitude scale (gLMS) used widely to assess sensory evaluations (Bartoshuk et al., 2002), recognizes that such ratings may not be truly linear, and that contrasts of ratings between participants may be confounded by different interpretations of the anchors of unlabeled VAS (Hofmans & Theuns, 2010; Wewers & Lowe, 1990). To get around this, the AgLMS consists of a forced choice of like or dislike, followed by a rating of the strength of liking/disliking on a continuous scale but with clearer definition of the levels of liking at each level of motivation. Although the

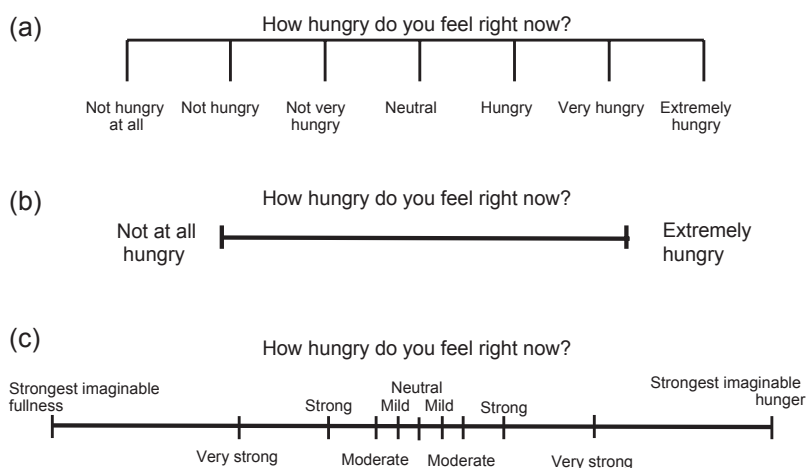


FIGURE 6.2 Examples of rating scales commonly used in appetite studies. (a) Seven-point Likert scale, (b) visual analogue scale, (c) the affective generalized labeled magnitude scale.

gLMS has clear advantages when measuring sensory evaluations (Bartoshuk et al., 2002), whether the AgLMS approach has true advantages over the VAS remains unclear, and the VAS remains the most widely used scale for measuring our experience of appetite.

A critical question to consider is what wording should be used to delineate the extremes of appetite rating scales. This in turn raises the related question of whether such ratings should be unipolar (i.e., measuring from nothing to maximum for the rated state) or bipolar (with anchors that are conceived as polar opposites: for example, extreme hunger at one end and extreme fullness at the other). A bipolar approach is supported by the suggestion that ratings of appetite, hunger, and fullness may all measure a single motivational variable, desire to eat (Booth, 1987). If we apply Occam's razor, this approach makes scientific sense because it offers the simplest conceptual interpretation of our conscious experience of appetite, unless there are clear experimental findings that dissociate these ratings. Indeed, in the case of hunger and fullness ratings, it is clear that gross patterns of change in hunger and fullness tend to mirror each other: people reliably rate reduced hunger and in parallel increased fullness as a typical meal progresses. However, it is now clear that there are subtle differences in the way these ratings change within an eating episode that suggest that participants can distinguish to some extent between feelings of fullness (which in general reflects the amount of food consumed) and feelings of hunger (the desire to eat more). Perhaps the clearest dissociation between hunger and fullness comes from studies of the effects of gastric distension. For example, increasing gastric distension using a barostat reliably increased ratings of fullness, but did not have an impact on ratings of hunger (Carmagnola, Cantu, & Penagini, 2005). Likewise, infusion of the gastric hormone cholecystokinin (CCK) reduced rated fullness but did not reliably alter rated hunger (Melton, Kissileff, & Pi-Sunyer, 1992), although the combination of CCK and gastric distension reduced both hunger and fullness. Along with other findings (Feinle, Grundy, & Read, 1997; Yeomans, 2000), these data suggest that people can distinguish between feelings associated with a full gut (fullness) and a desire to eat (hunger). These findings also invalidate experimental approaches based on bipolar rating scales that treat appetite as a linear scale between "extremely full" and "extremely hungry" (e.g., Cardello, Schutz, Leshner, & Merrill, 2005): although hunger and fullness are correlated measures, the subtle differences that emerge from detailed analyses of these ratings confirm they add greater value when analyzed separately than as a single dimension.

Historically, ratings of appetite have had a large influence on the development of key theories in human appetite, particularly when combined with ratings relating to the sensory characteristics of the ingested food. Two classic examples are how changes in ratings of food pleasantness combined with hunger ratings were critical to the development of the concept of negative gustatory alliesthesia (Cabanac, 1971, 1979; Cabanac, Duclaux, & Spector, 1971) and later for sensory-specific satiety (Rolls, 1986; Rolls, Rolls, Rowe, & Sweeney,

1981). But as the numbers of studies and labs using appetite ratings increased, it became increasingly evident that there was a need to standardize the wording of questions used to assess human appetite. In an important methodological review bringing together many key researchers (Blundell et al., 2010), the strong recommendation was made that assessments of human appetite should be based on five key questions, assessing hunger (“How hungry are you?”), fullness (“How full are you?”), satiety (“How satiated are you?”), desire (“How strong is your desire to eat?”), and prospective consumption (“How much do you think you could (or would want to) eat right now?”). All five questions were to be presented as a VAS, and these recommendations have been widely adopted.

Alongside some degree of agreement on what questions should be asked in studies of appetite has been a shift from the original ratings made on paper to increasingly sophisticated electronic ratings. As technology has advanced, early VASs on computers have evolved through a succession of devices, starting with early hand-held devices like the Apple Newton (Stratton et al., 1998) and the Compaq IPAQ (Hull, Re, Tiihonen, Viscione, & Wickham, 2012, 2014) and progressing to the latest devices like the iPad Mini (Brunger et al., 2015). Electronic recording of these ratings minimizes the errors in data recording and entry that were a risk when experimenters had to measure scores on 100-mm paper-based VASs by hand, and ensures that the data meet the most stringent regulatory demands for experimental studies.

But no rating scale will ever be perfect. Rating scales attempt to tap into our conscious awareness of our desire to eat. However, they rely on both the accuracy of introspection and participant honesty. It is easy to imagine situations in which the demand characteristics of a study might reduce the likelihood of a participant giving an accurate self-report of his or her appetite: a participant with a weight problem being asked to rate his or her desire to eat when confronted with a highly desired food such as chocolate might be such a case, because a strong self-reported desire might be seen as socially unacceptable. Likewise, there are instances in which self-reported appetite clearly cannot be a reflection of underlying nutritional needs, for example, in the very low ratings of hunger given by many sufferers of anorexia nervosa faced with a meal (Halmi & Sunday, 1991), which is likely to reflect the nature of their eating disorder rather than their actual biological need state.

A further potential issue with rating scales is that their very subjective nature makes it hard to draw firm conclusions from studies that try and compare absolute ratings between population groups. In contrast these ratings can be highly informative about subtle effects of various appetite manipulations in the context of experimental studies that contrast changes in appetite over time within a participant. There is no doubt that the use of subjective measures of appetite has added a great deal to our understanding of many aspects of controls of eating, but these data should always be viewed with some caution.

3. MICROSTRUCTURAL APPROACHES TO STUDYING HUMAN EATING BEHAVIOR

Although overall intake measures are ultimately the most widely cited measures of eating, as they allow measures of nutrient intake, more detailed analysis of how the food was consumed gives the researcher additional tools to explore hypotheses about the mechanisms and influences that modify intake. Collectively this approach has become known as microstructural studies and has its origins in studies of feeding in nonhuman animals. Early microstructural approaches adopted a variety of techniques, starting with the use of a hidden observer to monitor someone drinking from a liquid dispenser (Jordan, Wieland, Zebley, Stellar, & Stunkard, 1966) and then progressing to more sophisticated methods as technology advanced (see Guss & Kissileff, 2000, for a review of early studies). The most commonly used microstructural approach today is some variation of the UEM first described by Kissileff et al. (1980). The UEM (Fig. 6.3) consists of a hidden balance on which the to-be-consumed meal is placed: the progressive reduction in weight across a meal gives an approximation of progressive intake, allowing the experimenter to assess a number of measures beyond simple intake. Further elaboration of this approach by using continuous weight data to trigger requests for participants to repeatedly rerate appetite within an eating episode (Yeomans, 2000), for example, using the Sussex ingestion pattern monitor, has allowed this approach to provide ever more detailed accounts of ingestion.

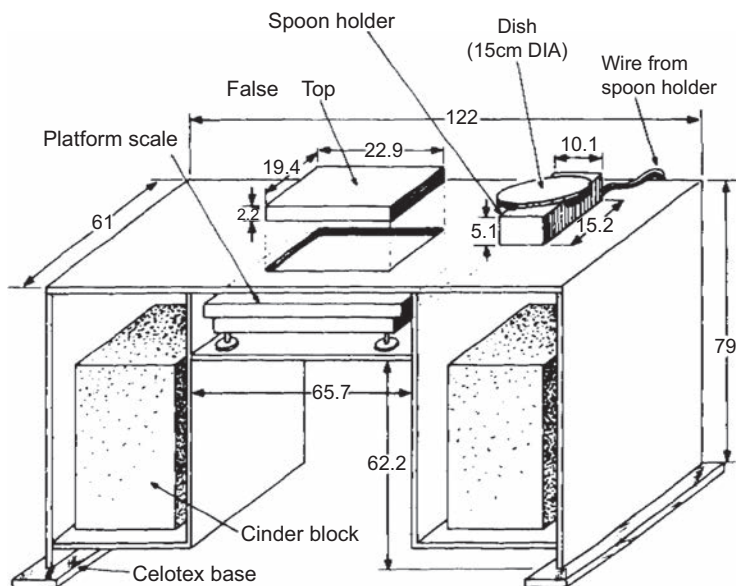


FIGURE 6.3 The universal eating monitor described by Kissileff et al. (1980).

Key measures beyond simple intake generated by this approach include:

- Eating rate: how much food is consumed as a function of time
- Meal duration: how long people spend eating
- Bite size: how much is ingested at each mouthful
- Cumulative food intake: the pattern of intake across the meal as a function of meal duration

In terms of experimental design, the same factors and limitations are seen with these types of studies as with any laboratory-based intake measure. But the progressive monitoring of intake also generates additional constraints: for example, the habit of leaving cutlery on a plate during eating adds a complication to interpretation of the weight data, solved in the UEM by a separate rest for cutlery outside the weighing area. The UEM approach also attempts to be covert: participants are not routinely made aware of the monitoring of intake. However, in a variation on the UEM, the Mandometer (Bergh, Brodin, Lindberg, & Sodersten, 2002; Zandian, Ioakimidis, Bergh, Brodin, et al., 2009; Zandian, Ioakimidis, Bergh, & Sodersten, 2009), participants are made explicitly aware that intake is being monitored and indeed their rate of ingestion is fed back to them as a form of biofeedback aimed at treating undereating in anorexia (Bergh et al., 2002) or overconsumption in obesity (Ford et al., 2010). Thus over time the monitoring of intake has progressed to ever more sophisticated methods that more focused on testing ideas about appetite control.

4. THE ADVANTAGE OF MULTIPLE MEASURES

Although all of the measures of appetite discussed so far have provided valuable insights into our understanding of eating behavior in their own right, many of the most insightful studies accept that the use of single independent measures has major limitations. For example, let us propose that a pharmaceutical company is developing two new drugs (drug A and drug B), which, in preclinical trials, clearly reduce food intake and which therefore may have potential as drug treatments for obesity. A simple test of the drugs' efficacy in human participants, once these drugs' safety has been established, might be to contrast intake in a defined period after taking these drugs using a double-blind, placebo-controlled study. Consider that the outcome measure, reduced food intake, was clearly evident for both drugs. Does this constitute clear evidence of these drugs' efficacy in reducing appetite? From one perspective it clearly does, because acute intake is reduced, but in reality we know that many drugs potentially reduce food intake by generating side effects rather than by targeting the specific controls of appetite. If the researchers had included both measures of subjective appetite and a battery of ratings of potential adverse reactions, they could have further determined the mechanism leading to reduced intake. Inspection of these data might show, for example, that despite both drugs reducing food intake and rated appetite at the start of the test meal, drug A also caused increased nausea before

eating started. These data suggest that drug B would be a better potential candidate as an antiobesity agent, whereas drug A was probably affecting intake through a nonspecific adverse reaction. This simple example is an approach well founded in behavioral nutrition, and in practice combinations of measures have provided insights that could not have been found with simple intake or appetite measures alone. A further example of the value of multiple measures is illustrated in Fig. 6.4. In the top two panels we see overall intake of a simple food (pasta with tomato sauce) under two conditions (a test and a control). Note that in each case intake in the experimental condition is about 30% lower than in the control. Thus based on intake data alone we cannot discriminate between these two sets of data. However, on the bottom two panels we see rated hunger throughout each meal as a function of amount consumed, and now clear differences in behavior emerge. As can be seen in Fig. 6.4(d), hunger at the start of the test meal was lower in the test than in the control condition, but that the change in hunger within the meal was similar in both conditions [including an initial increase in intake when food was first tasted: the appetizer effect (Yeomans, 1996)]. Thus the difference in intake can be attributed to the reduction of appetite induced by the test manipulation. This makes sense, since the right side shows intake at a test meal consumed 30 min after consuming a bowl of low (control) or higher energy (test) soup (Yeomans, Gray, & Conyers, 1998). In contrast, the change in hunger as a function of intake in the lower left-hand graph (Fig. 6.4(c)) is very different. Here there was no difference in hunger at the start of the test meal, but instead the reduced intake in the test condition can be attributed to the lack of initial increase in hunger once eating started. In this case (Yeomans & Gray, 1997), the data show intake after treatment with the opioid receptor antagonist naltrexone (test) relative to placebo (control): naltrexone has been shown to reduce liking for the flavor of food (Fantino, Hosotte, & Apfelbaum, 1986; Yeomans & Gray, 1996), and it is that effect that probably reduced intake. The key point is that the additional behavioral detail could discriminate between these two very different manipulations when intake measures alone could not.

Previous research strongly supports the value of a microstructural approach. Thus the rate at which eating progresses, the overall duration of a meal, bite rate, etc., all give clues about the nature of appetite associated with that eating episode. Even more information becomes available if ratings of appetite are included progressively across the meal and are then related to the amount consumed. Such analyses have in the past shed light on many aspects of appetite, including the effects of palatability (Yeomans, 1996; Yeomans, Gray, Mitchell, & True, 1997), the differences between the effects of manipulations of satiation and satiety on appetite during a meal (Gray, French, Robinson, & Yeomans, 2002, 2003; Yeomans et al., 1998; Yeomans, Lee, Gray, & French, 2001), and most recently how expectations about satiety interact with actual nutrients to alter appetite during meals (Masic & Yeomans, 2014b; Yeomans, 2015; Yeomans & Chambers, 2011). Studies using the UEM approach have also been able to provide a fuller account of the effects of drugs that modulate appetite, such as meta-chlorophenylpiperazine (Thomas,

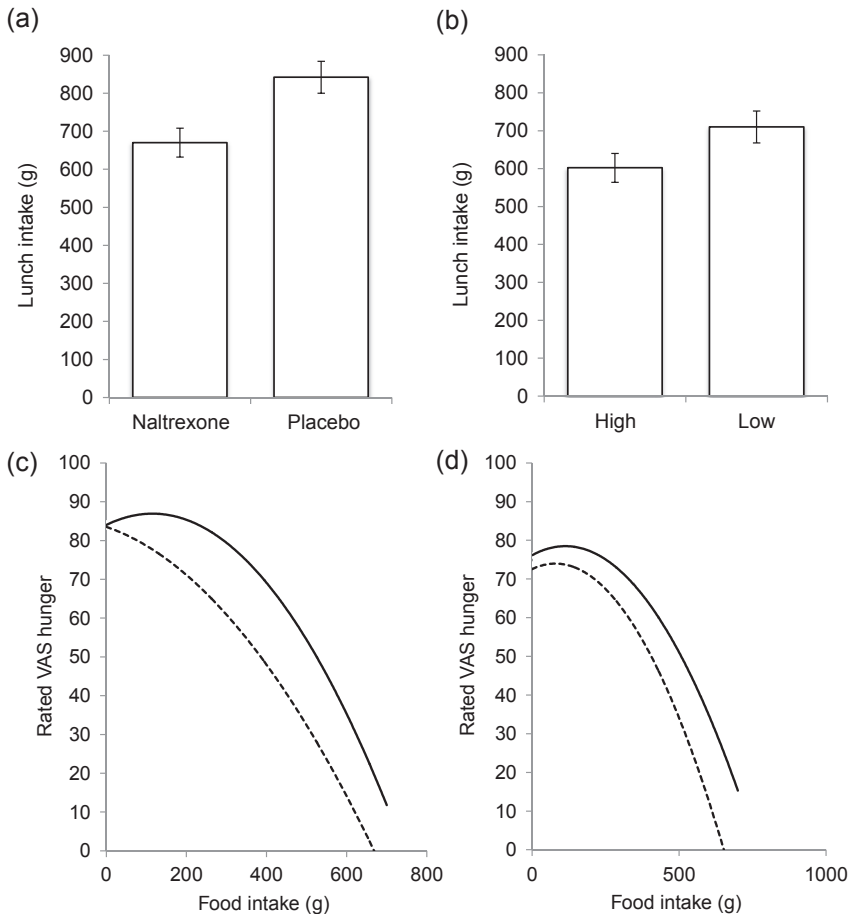


FIGURE 6.4 How combinations of intake and appetite data are more informative than either measure alone. (a and b) Overall intake of a simple pasta and sauce lunch (g) under test or control conditions: for (a) the test was administration of the opioid receptor antagonist naltrexone and the control a placebo, for (b) the test was prior consumption of a higher energy (238 kcal) soup and the control a lower energy (38 kcal) soup. (c and d) The average change in rated hunger across the course of these meals under the same test conditions: (c) the opioid antagonist study, *solid line*, placebo; *dashed line*, naltrexone; (d) the energy preload, *solid line*, lower energy; *dashed line*, higher energy preload. VAS, visual analogue scale. (Data in (a)/(c) are redrawn from Yeomans, M. R., Gray, R. W., Mitchell, C. J., & True, S. (1997). Independent effects of palatability and within-meal pauses on intake and subjective appetite in human volunteers. *Appetite*, 29, 61–76 and (b)/(d) from Yeomans, M. R., Gray, R. W., & Conyers, T. (1998). Maltodextrin preloads reduce intake without altering the appetiser effect. *Physiology and Behavior*, 64, 501–506.)

Dourish, Tomlinson, Hassan-Smith, & Higgs, 2014), test the effects of added spices on vegetable consumption (Li et al., 2015), show how larger portion sizes alter eating rate and bite size (Almiron-Roig et al., 2015), etc. Thus the UEM approach can be adapted to test hypotheses over a very wide range of interests, adding clarity and accuracy to measures of intake.

Overall, this brief overview demonstrates how adding measures beyond simple intake has provided important insights into the fundamental processes underlying appetite control, and how these may be disturbed to allow overeating or anorexic behavior. It demonstrates clearly the value of the UEM approach as part of the appetite researcher's toolbox to gain the most detailed accounts of human ingestion.

5. DESIGNING INTAKE STUDIES: A CASE STUDY

As has been noted elsewhere (Gibbons et al., 2014), with measures of appetite and intake there is no one study design that is suitable for addressing all of the myriad questions that appetite researchers wish to test. However, working through the decisions underpinning the final design of a particular study should provide the reader with greater insight into how to use the techniques described here optimally in a given situation, allowing the understanding this brings to enhance future study design.

The study in question set out to examine the likely impact of enhanced umami taste on both appetite and satiety (Masic & Yeomans, 2014b). The hypothesis was that umami taste has two almost opposing effects in the context of ingestion. First, compounds that generate umami taste were predicted to act as flavor enhancers, and through this action to increase liking for the overall flavor of the ingested food. The short-term effect of increased liking is an increase in rated hunger in the initial stages of eating (Yeomans, 1996); thus the key test required the combined collection of rating data alongside intake data during a meal. The ideal solution was to use a UEM, which could prompt participants to rate their appetite throughout the test meal, with the interval between ratings determined by weight consumed. This allowed a direct contrast of the pattern of change of appetite as a function of intake within an eating episode for the same food with and without added umami taste. Second, based on the prediction that umami taste acts as a sensory cue for the likely presence of protein (Kurihara, 2009; Luscombe-Marsh, Smeets, & Westerterp-Plantenga, 2008; Naim, Ohara, Kare, & Levinson, 1991), and the enhanced satiety seen with protein relative to other macronutrients (Bertenshaw, Luch, & Yeomans, 2008; Paddon-Jones et al., 2008; Veldhorst et al., 2008; Westerterp-Plantenga, Lemmens, & Westerterp, 2012), it was predicted that consuming umami-enriched food would increase subsequent satiety and so lead to less food being consumed later. Thus the study needed a second meal after the initial ingestion of the umami-rich food to test the satiety part of the hypothesis. Moreover, because the prediction was a greater effect of added umami if the food contained protein, a second manipulation was needed to contrast the umami manipulation between a lower energy and a higher energy protein-rich variant. The overall design was therefore essentially a classical preload study, with manipulation of umami taste and nutrient content using a 2x2 design as the preload and a test meal following later.

What test foods would be most appropriate? The key food was the test food, which was both to be flavor-enhanced with umami and to allow covert manipulation of nutrient content. Here, a low-energy soup was developed that was also naturally low in umami taste, and whose flavor was enhanced by a combination of monosodium glutamate (MSG) and inosine monophosphate to enhance umami taste in the test condition. Because the second meal was testing the satiety response and not food choice, a simple pasta meal was adequate. How long between the first and the second meal? Here the timing of the test meal was determined based on an earlier study that had measured the effects of added MSG on rated appetite postingestion: the chosen time (45 min) was when there was the largest difference in rated appetite between MSG-enhanced and control soups (Masic & Yeomans, 2013). And finally, how to try to minimize demand effects? The complexity of the design would have made it difficult for participants to “guess” the aims, but as a further distractor, participants were told the study examined the effects of food on motor performance. This focused attention away from the two test hypotheses, while inclusion of a simple motor task between sessions helped reduce the potential boredom associated with being tested with similar meals on four separate test days. Overall the study shows how attention to detail is essential in the design of effective laboratory studies of ingestion.

6. IN SUMMARY

This chapter has tried to summarize the key measures used to assess appetite and food intake in human studies, with special consideration of the experimental decisions that are key to study success in this area. There are other approaches to measuring behavior that were beyond the scope of this discussion, such as a more detailed evaluation of FFQ measures, etc., while specific approaches to assessing satiation (i.e., changes in appetite within a meal) and satiety (the suppression of appetite after eating) are discussed elsewhere in this book. Intake measures will always be key to any study of human eating or drinking, and consideration of the issues raised in this chapter should help researchers take into account the inherent problems associated with trying to measure intake in human volunteers. A key message from this chapter is that intake measures alone give only a very crude assessment of appetite, and that the clearest answers may be seen when multiple measures are taken and used in combination.

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Chapter 7

Measuring Satiation and Satiety

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1. INTRODUCTION

The initiation and termination of an eating episode is a complex behavior that involves many regulated parameters. Consumer food intake and postingestive experience are quantifiable and provide important insights into the habitual dietary patterns and intake behaviors that inform health and well-being. However, at the heart of these measures are human subjects, with all the subjectivity, idiosyncrasy, and complexity often associated with human sensory and consumer testing. In recent years there has been a rise in functional satiety claims for foods, with terms like “fuller for longer” used to describe a satiating product experience. For these claims to be credible, experimental findings must be reliable and reproducible if they are to support product development or claim substantiation. To ensure these data are robust and reliable, guidelines have been developed for accurate, reproducible, and discriminative approaches to measuring different aspects of the satiating properties of foods. There is an increasing awareness among sensory and consumer science researchers of the need to go beyond one-sip hedonic appraisals, to understand the experience of consuming a full product or meal and the subsequent postingestive experience (Lesdéma et al., 2016). This includes understanding eating behaviors that emerge during a meal, differences in the filling properties of different foods, the duration and quality of the fullness perceived, and the impact consumption has on later energy intake. This information enables a deeper understanding of the psychobiology of eating and the complex relationship between appetite, food choice, and energy intake regulation. In the past a significant focus in the satiety field has been on the satiety experience of consuming foods that differ in macronutrients or energy (Rolls, Hetherington, & Burley, 1988).

A wide range of factors influence the onset, timing, and duration of satiety feelings and these have been summarized in the “satiety cascade,” which illustrates the different timings of onset between satiation and satiety and the relative contributions of sensory and physiological influences (Fig. 7.1) (Blundell, 1991). Food sensory properties have an important role early in the satiation process, directing food choice behavior and informing portion selection premeal,

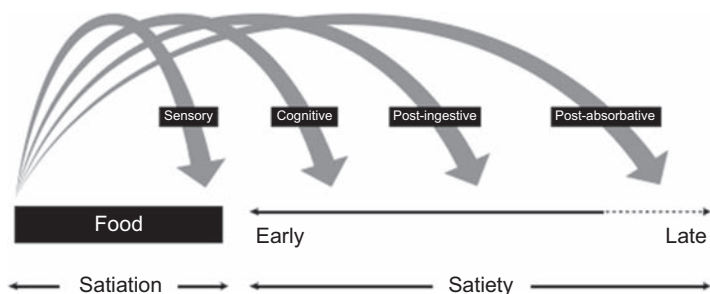


FIGURE 7.1 The satiety cascade. (Adapted from Blundell, J. (1991). *Pharmacological approaches to appetite suppression*. Trends in pharmacological sciences, 12, 147–157.)

and in the oral metering of calorie intake within a meal (McCrickerd & Forde, 2016). Physiological and endocrine processes have a strong influence later in the meal (Fig. 7.1). Accurately quantifying the factors that influence food intake within a meal, and from meal to meal, is central to an understanding of eating behaviors and the etiology of obesity, and can be used as the basis for approaches to improve weight management. As with sensory tests, the approaches used to measure food intake and quantify the human subjective experience serve to control, partition, and reduce unwanted bias among the measures to yield an objective impression of the filling properties of foods. This chapter summarizes the most commonly used methods for quantifying satiation, satiety, and eating microstructure and will introduce the recently developed approach to measuring “expected satiety” for different foods.

2. A DEFINITION OF SATIATION AND SATIETY

Before discussing how best to measure satiation and satiety it is first necessary to define them, as these terms are often confused and used interchangeably, though both describe sensations that are physiologically and behaviorally distinct. Satiation describes the series of processes that bring a meal to an end, and is frequently associated with meal size (g or kcal). Satiety is used to describe the postingestive processes that occur after a meal and inhibit further eating, and includes the suppression of hunger and a feeling of fullness during the intermeal period, and is usually associated with measures of time until the next meal and/or later meal or snack intake (kcal) (Blundell et al., 2010). These processes are separate but overlapping, and both should be considered when evaluating the satiating properties of a food (Livingstone et al. 2000). A study to understand the satiation properties of a food is focused on the intrameal period and measures energy intake, weight, or volume and changes in the subjective appetite feelings that occur before, during, and at the end of the meal itself. Satiation controls the size of a meal, whereas satiety is responsible for the duration of the intermeal interval, the frequency of eating, and the subjective appetitive feelings during the intermeal period. Satiety between meals can be quantified by tracking subjective feelings of hunger and fullness, time to the next meal, and energy intake at the next meal. Satiety can also be reflected in physiological measures such as gastric emptying or circulating levels of appetite peptides (Delzenne et al., 2010; Mars, Stafleu, & de Graaf, 2012). Differences between satiation and satiety are important to understand conceptually, as they help explain the theoretical independence of the techniques used in their measurement. Each sensation has distinct endocrine and physiological pathways that underpin the duration and intensity of their expression and are manifest as differences in behavior (Fig. 7.1).

Both the intensity and the duration of satiation and satiety can vary depending on the caloric, macronutrient, and sensory properties of the foods tested and an individual’s response. As satiation describes the factors that lead to the end

of the meal, key influences include food form (liquid, solid), energy density (kcal/g), and macronutrient composition (percentage of energy from fat, carbohydrate, protein), as well as the predominant sensory properties and intensities, including the palatability and variety of foods served. Satiety tends to be more influenced by food composition and total calories consumed, though clearly there is a strong interrelationship with satiation, as the amount consumed within a meal (satiation) strongly influences the feeling of fullness, duration of fullness between meals, and amount of energy consumed at a later meal.

Studying eating behaviors under the controlled conditions of the laboratory affords the opportunity to study psychobiological influences of energy selection and intake and, through well-designed and controlled studies, establish an understanding of factors that influence human appetite control. In an ideal world it would be possible to profile eating behaviors and energy intake across all meals and over time, controlling for the sensory and macronutrient composition of all foods consumed. However, in reality this is impractical. In the same way hedonic ratings on a 9-point scale are an approximation of liking, it is important to recognize that satiety techniques are at best an estimate of what occurs naturally in the real food environment, where product information is available, portions are often predetermined, and a wide range of social and psychological factors influence food choice and intake. Despite these limitations, the techniques presented hereafter describe the different approaches used to measure satiation and satiety.

3. MEASURING SATIATION AND SATIETY

Fig. 7.2 provides a schematic overview of several different approaches used for the measurement of satiation (Fig. 7.2(a)) and satiety (Fig. 7.2(b)–(d)) and an example of the application of each approach and key outcomes for comparison. An overview of the approaches used to measure satiation and satiety is provided next.

3.1 Measuring Satiation

An *ad libitum* meal paradigm is typically used to measure satiation, and in it the total energy or weight of food consumed to fullness is recorded and related back to either the properties of the test food or meal or differences within the group of subjects consuming it (Chapelot, 2013). Within this same *ad libitum* meal paradigm it is also possible to capture food choice (Allirot et al., 2012), the microstructural patterns of eating during the meal (Bellisle & Le Magnen, 1980; Bolhuis et al., 2014), temporal changes in appetite feelings (Yeomans, 2000), and the reasons for cessation of eating (Mook & Votaw, 1992). This will be described in more detail later, when we focus on selecting test foods and additional measures. Regardless of the test food and meal paradigm chosen, numerous studies have shown that crossover (or paired/repeated measure)

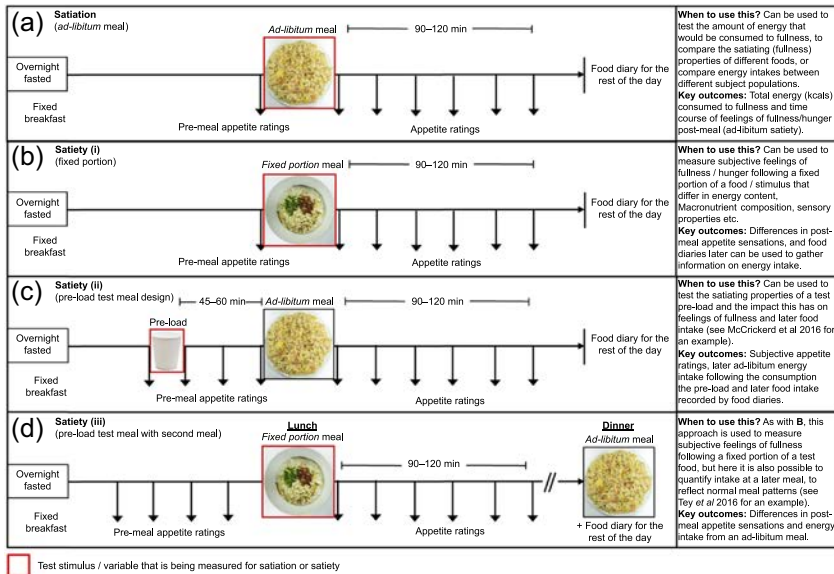


FIGURE 7.2 Examples of different test protocols for the measurement and comparison of (a) satiation and (b–d) satiety.

designs should be applied as a rule whenever possible instead of between-groups designs, as interindividual differences in food intake responses are large and may lead to unreliable data (Arvaniti, Richard, & Tremblay, 2000; Blundell et al., 2010; Chapelot, 2013; Gregersen et al., 2008). For example, crossover designs are appropriate when comparing the effect of an ingredient on fullness within the same group of subjects, whereas between-groups may be more appropriate when the outcome of the study can be significantly influenced by memory or learning and where balancing the order of presentation will not suffice in removing this effect. An example would be a study that seeks to explore the impact of high and low satiety labeling on subsequent food intake for the same food, where a washout period would be insufficient to remove the influence of the first session. Although less commonly used, between-groups designs are useful under specific circumstances provided each group is adequately powered to reduce interindividual variation in appetite responses.

3.2 Measuring Satiety

Satiety captures the intensity and duration of the feelings of fullness derived from an eating event, and includes the subjective feeling of fullness between meals and the timing and extent of later calorie intake as key outcomes. A key distinction between the measurement of satiation and the measurement of

satiety is that the latter considers temporal changes in subjective feelings of hunger and fullness for the energy consumed and impact of these feelings on the timing and extent of later energy intake (Chapelot, 2013). Satiety measures reflect changes in subjective motivation to eat between two time points and can be measured using fixed portions, preloads, or ad libitum test meals. Satiety can therefore be measured by (1) tracking changes in subjective need states over time (i.e., hunger/fullness/desire to eat) or by (2) measuring the duration between the treatment and the next meal and the intake at the next meal following the experimental treatment. Based on this, there are multiple outcomes used to measure satiety feelings. These are summarized in the following as either measures based on subjective feelings or objective measures of intermeal duration and later food intake.

3.3 Measuring the Intensity of Subjective Appetite Feelings

3.3.1 *The Scaling of Appetite Need States*

The scaling of appetite need states is usually captured on 100- or 150-mm visual analogue scales (VAS) and follows many of the same principals as described elsewhere for sensory attribute ratings (Lawless & Heymann, 2010). The reproducibility and reliability of a VAS line scale of appetite feelings have been extensively reviewed elsewhere (Flint, Raben, Blundell, & Astrup, 2000; Stubbs et al., 2000) and show good repeat reliability at the group level, but variable repeat reliability at the individual level. Most research recruits a minimum of 20–25 subjects to capture a 10% difference in average subjective appetite ratings between foods, with larger samples required for between-subjects comparisons and studies with multiple experimental conditions (Flint et al., 2000). These measures tend to be more robust in response to defined experimental manipulations compared to studies attempting to associate appetite feelings with satiety biomarkers (Blundell et al., 2010). The VAS line scale approach is widely applied because it is cheap, easy to understand and analyze, and predictive of later energy intake. In a review of 23 randomized eating studies, Sadoul and colleagues highlighted that a difference in appetite motivation VAS ratings of ≥ 15 –25 mm on a 100-mm line scale was sufficient to predict a significant change in later energy intake (Sadoul, Schuring, Mela, & Peters, 2014). In a metaanalysis of 462 studies it was concluded that self-reported appetite ratings do not reliably predict energy intake and emphasized the need for caution when inferring later intake from appetite ratings alone (Holt et al., 2016).

Category scales can also be applied instead of VASs and the two have been shown to have similar discriminative power (Jeon, O'mahony, & Kim, 2004), and subjects can make ratings on paper or using a computer-based electronic appetite rating scale (Almiron-Roig et al., 2009). Before the scales are presented to participants, attributes must be clearly defined using terms that are unambiguous and clearly understood by all participants, should be

appropriately anchored, and should be unidimensional and not try to capture two sensations on the same scale. For example, ratings for hunger and fullness are not appropriate scale anchors on the same scale as it cannot be assumed there is an inverse or linear relationship between these feelings. When measuring satiety intensity posttreatment, a range of appetite need state measures should be taken at fixed time points after the meal or preload treatment. The choice of appetite attributes to be scaled posttreatment should be led by the hypothesis being tested and it is not advisable to measure multiple attributes and then post hoc select only the scales that produce the best result. An advantage of the VAS line scale approach is that it is reproducible and requires minimal data handling. Typically this involves measures of hunger, fullness, thirst, and desire to eat at baseline, before the treatment, and thereafter every 15 or 30 min for 90–120 min. Fullness is defined as the absence of hunger, whereas hunger is defined as a measure of the motivation to eat (Rogers & Hardman, 2015). Prospective consumption is often captured and is defined by asking how much a subject feels he or she could eat at that given moment. It is also possible to capture changes in food liking and palatability both during and after the treatment or test meal, and there is an important distinction to be made between the two. Palatability of a food will decrease the more of it you eat, as it is influenced by hunger and fullness; whereas food liking should remain stable and not be as influenced by need state (Rogers & Hardman, 2015).

Fig. 7.3 summarizes examples of some of the approaches used when scaling appetite sensations. Beyond the traditional VAS line scale (Fig. 7.3(a)) and category scale ratings (Fig. 7.3(b)) of appetite feelings, others have further developed composite measures of need state, such as the SLIM scale (satiety labeled intensity magnitude scale), in which several attributes can be combined (Fig. 7.3(c)). To avoid ceiling effects when scaling with appetite sensations, the labeled magnitude scale has been developed to cover appetite sensations (Solah et al., 2015). The SLIM is a vertical, 100-mm, bidirectional hunger–fullness scale that incorporates phrases describing different levels of hunger/fullness along the length of the scale, with “greatest imaginable fullness” and “greatest imaginable hunger” serving as anchors. SLIM has been shown to have sensitivity similar to that of the VAS for measuring perceived appetite (Cardello, Schutz, Leshner, & Merrill, 2005; Karl, Young, Rood, & Montain, 2013). More recently, new approaches have emerged using meal pictures to contextualize the ratings of prospective consumption, and these have demonstrated improved discrimination over traditional VAS hunger and fullness scaling (Sadoul et al., 2012). Finally, there are also a range of nonverbal/unlabeled techniques using pictures that can be used when scaling hunger and fullness sensations (Fig. 7.3(d)). These intuitive scales provide category-level information and can be used with subjects that have poor literacy or to avoid the need for translation of scale instructions or anchors. When studying fullness and hunger among children, we cannot assume they will understand the scaling approach or

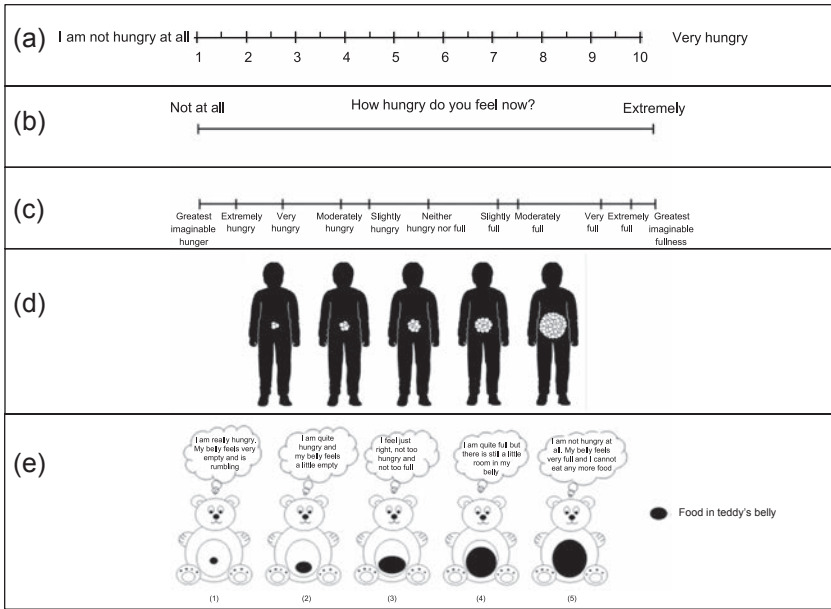


FIGURE 7.3 Subjective scaling of appetite sensations. (a) Satiety score card, (b) visual analogue scale, (c) satiety labeled intensity magnitude scale, (d) unlabeled visual hunger/fullness category scale, and (e) “Teddy the Bear” hunger and satiety rating scale. ((c) From Solah, V. A., Meng, X., Wood, S., Gahler, R. J., Kerr, D. A., James, A. P., et al. (2015). *Effect of training on the reliability of satiety evaluation and use of trained panellists to determine the satiety effect of dietary fibre: A randomised controlled trial*. PLoS One, 10, e0126202. (e) From Bennett, C. & Blissett, J. (2014). *Measuring hunger and satiety in primary school children. Validation of a new picture rating scale*. Appetite, 78, 40–48.)

the visceral feeling of hunger and fullness sensations. A new scale has been developed for research on satiety feelings with children (Bennett & Blissett, 2014). The scale is supported by a story to engage children to recognize feelings of hunger and fullness through a character named “Teddy the Bear” and has been validated for use with children to facilitate accurate and reliable ratings of hunger/satiety in children for whom abstract sensations like hunger and fullness can be difficult to interpret and quantify (Fig. 7.3(e)).

3.3.2 Time Course and Indices of Satiety Sensations

As we often have no a priori knowledge of the timing of onset or decay of the fullness imparted by a test stimulus, often before formally running the satiety trial it is advisable to run a time course analysis to understand the changes in appetite sensation over time for a specific stimulus. This enables the experimenter to design a test protocol that maximizes the sensitivity of the comparisons between the test stimuli being compared. For example, if the test includes

both sensory and energy density manipulations within a set of products, the sensory effect would be expected to occur early in the time course, but the macronutrient or energy density effects will probably have their own time course and will be dependent on gastric emptying rate and assimilation of energy postingestively. If the time course of appetite measures postingestion is too short, it is possible to miss the key periods of satiety that discriminate between the food treatments being compared. Once the optimum time course for the measures has been defined, the intensity of the different appetite ratings is captured at each time point pre- and posttreatment, usually at 15- or 30-min intervals. These ratings can be plotted to compare the slope, maximum rise, and decay of the feelings hunger/fullness for each test treatment. These ratings capture the subjective impression of the satiety imparted by a test treatment, and so can be averaged across individuals at each time point to enable a robust comparison of the subjective experience of each condition. Fig. 7.4(a)–(c) shows examples of such curves for (Fig. 7.4(a)) rated hunger and fullness over time, (Fig. 7.4(b)) the key peaks and troughs used for comparison of fullness over time, and (Fig. 7.4(c)) a hypothetical example of a curve for a fullness comparison between two food stimuli. From these plots, it is possible to compare the intensity and experience of satiety for each treatment by the rate of onset and decay of changes in the ratings (slope), the timing and intensity of the maximum feeling of fullness imparted (“peak fullness”), and the total duration of satiety experienced (area under the curve). Owing to the large individual variations in appetite ratings, averaged scores should be taken at each time point for the area under the curve (AUC) calculation, as this is much better than individual absolute ratings at single time points (Flint et al., 2000). The AUC is typically calculated using a trapezoid approach and can be compared for incremental AUC, which provides a summary of the onset and decay of the feeling of fullness, or total AUC, which provides a total for the fullness perceived across test treatments (Fig. 7.4(b)). The “satiating power” of the treatment can then be derived by dividing the total AUC for the fullness imparted by the energy (kcal) consumed for the test treatment (Blundell, Rogers, & Hill, 1987). A related measure called the “satiety index” can be calculated by looking at the ratio of the AUC for a test food or treatment to the AUC for a standard food (Holt, Brand, & Petocz, 1996; Weight, 1995). Similarly, it is possible to compare the functional benefit of food intake by deriving a “satiety quotient,” for which the difference in the hunger before and after food intake is calculated as a function of the energy content of the food consumed (Green, Delargy, Joanes, & Blundell, 1997). Finally, the “satiety ratio” can be derived as the ratio between meal size (kcal) and the latency to the onset of the next meal (time) (De Castro and Brewer, 1992). Collectively these indices offer a standardized approach for comparing subjective satiety experience per kilocalorie consumed, across treatments and test populations.

In 2016, a trained sensory panel approach was adopted to develop a high-throughput satiety panel approach for the objective comparison of the satiating properties of different foods. To achieve this, a group of sensory panelists

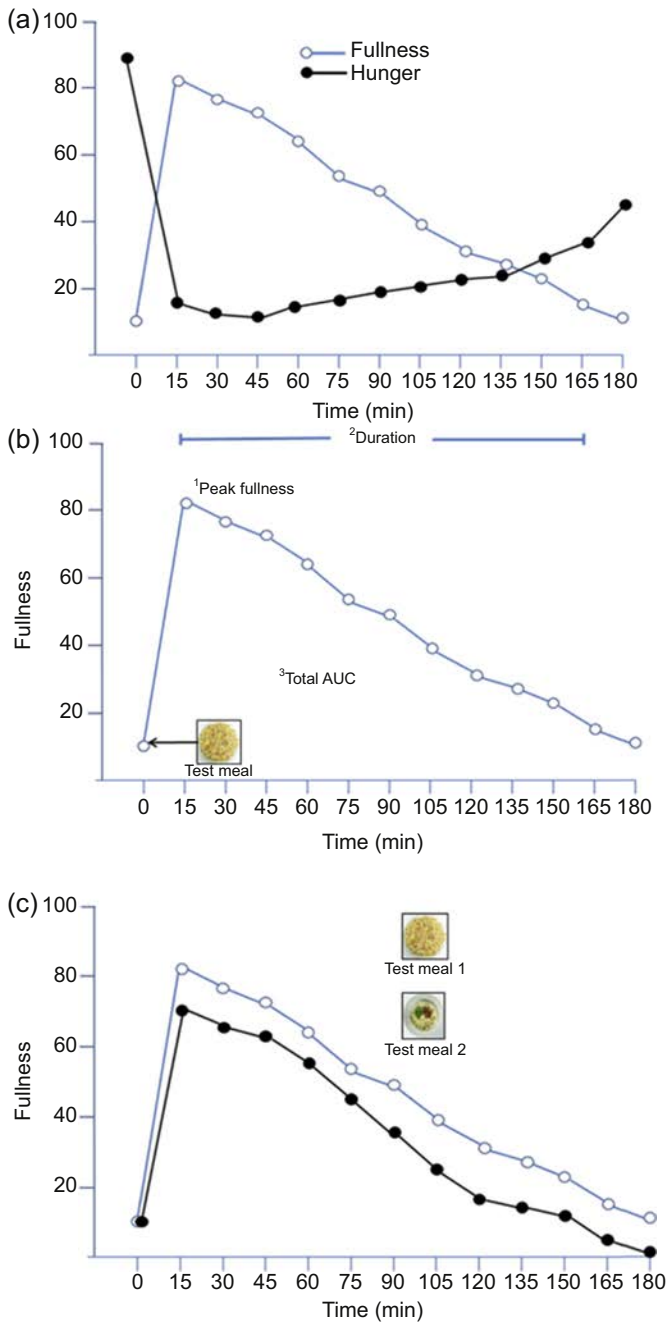


FIGURE 7.4 (a) Fullness and hunger curves, (b) satiety calculations, (c) fullness comparison between two samples. *AUC*, area under the curve.

underwent training to improve their use of an appetite vocabulary to scale sensations of hunger and fullness and reproducibly rate these sensations. Results from this approach were shown to be reproducible, and the approach showed stronger discrimination of perceived satiety for a set of cereal products than the same ratings made by a group of naïve consumers (Lesdéma et al., 2016). This new approach highlights a growing interest in the measurement of the subjective experience of satiety and creates an opportunity to rapidly screen products by differences in the satiety they can deliver. However, the satiety panel approach may lack ecological validity as it reflects real-life ingestive behavior poorly. For this reason it would be useful to use a satiety panel to screen differences in products, but to test the satiating efficacy of the foods in a more natural free living eating context.

3.3.3 *Equilibrating Participant Need State at the Beginning of a Food Intake Trial*

At the beginning of a food intake trial it is desirable that subjects arrive in equivalent need states, so that the visceral feelings of hunger, fullness, and desire to eat that will be measured over the course of a test session are similar at baseline before the test treatment or meal is consumed. It is not possible to fully control this owing to naturally occurring differences in eating patterns and differential energy requirements across the test population. One approach that is used to counter the variance from differences in starting need state is the use of the correct randomization procedure to ensure that the variance from small differences in need state is spread evenly over the different test days and treatments. In addition, it is common practice to advise against strenuous exercise the day before a trial, to discourage subjects from arriving with significant energy depletion that may prompt additional calorie intake, independent of the test variables being examined. Another approach is to provide subjects with a fixed-portion breakfast in an effort to standardize their appetite ahead of consuming the test meal of interest. To ensure that subjects arrive at an eating trial in similar need states, most studies ask subjects to:

- fast for a fixed period of time before the test meal, often overnight;
- abstain from excessive physical activity the evening before a test meal;
- consume a fixed breakfast at a fixed time to equilibrate subject need state ahead of a lunchtime test session;
- follow their normal dietary behavior in the days around a meal study.

Differences in need state should be captured in any meal trial as baseline measures, where hunger, fullness, desire to eat, and often the time since the last meal are recorded for each participant. These measures can then be used to compare need state against energy intake and further controlled for in the analysis of energy intake across days. Large variations in subjective need state at the beginning of a given test session can confound the comparison of the experimental variables under investigation. These differences can be further

controlled through the use of a crossover experimental design, which offers better control over individual differences in fullness and satiety as each individual subject acts as his or her own control.

Subjective differences in appetite ratings capture the perceived need state of an individual or group of individuals, but often these differences do not translate into differences in intermeal interval or later food intake. In this regard, if your ratings indicate you feel hungrier, you do not necessarily always eat more food. Appetite scales cannot be used as a substitute for a controlled eating behavior trial in which food intakes are accurately measured, as the relationship between food intake and perceived hunger is highly variable across subjects and based on energy consumed and the length of time after the treatment of each rating (De Graaf, 1993; Mattes, 1990; Yeomans & Bertenshaw, 2008). Appetite ratings made early or in the middle of the postmeal period are correlated more strongly with later food intake, whereas these differences become less important the longer after the meal the ratings are made (Gibbons, Finlayson, Dalton, Caudwell, & Blundell, 2014). To supplement subjective appetite ratings of satiety, behavioral satiety can be measured objectively as satiety duration by recording the time to the initiation of the next eating event and by recording the amount of energy consumed at the next meal.

3.4 Objective Measurement of Satiation and Satiety

To quantify satiation the experimenter should record the total ad libitum energy (kcal) consumed to fullness within a meal (Fig. 7.2(a)). To quantify satiety objectively it is necessary to measure the time to the next meal and/or the amount of energy consumed at the next meal (Fig. 7.2(b)–(d)). Measuring time to the next meal is based on the belief that energy intake homeostasis is maintained by eating frequency, and is applicable only when there is free choice on the time to the next meal for the subjects, and this timing can be accurately recorded in what is termed a “free satiety” paradigm. It is also necessary to avoid having obvious visual cues, such as watches or clocks present in the test room, as this may lead to a reliance on habitual eating patterns rather than individual motivation to eat driving the intake behavior. It is more common to measure the amount of energy consumed at the next meal, and for this measure it is necessary to standardize the time between eating events. Satiety is a combination of both the duration of the feeling of fullness and the adjustments to energy intake at the next meal, so where possible it is advisable to record both.

A common approach to measuring the satiety response to a food is to serve the test treatment as a preload and record intake of energy at a meal following a predefined time gap (Fig. 7.2(c) and (d)). The preload test design is widely used to estimate the short-term satiety effect of a test treatment. To avoid interindividual variation in satiety responses, it is best to run preload studies as a within-subjects design and have all subjects complete all conditions. Using the preload paradigm, satiety is measured by measuring ad libitum energy consumed to

satiation a fixed period of time after a test preload has been consumed, and then this response can be compared across treatments or benchmarked against a control condition (Blundell et al., 2010). The rationale behind the approach is that treatments that yield more satiety will lead to a reduction in ad libitum intake within a standard meal and vice versa (Fig. 7.2(c) and (d)). The key distinction between this approach and that taken for the measurement of satiation is that in a satiety test, the test treatment of interest is presented before the ad libitum meal, and the ad libitum meal is the same across premeal test treatments, such that intake can be measured and compared using this standard meal. For a satiation trial the ad libitum meal is the test variable and the experimenter is interested in how intake changes across different variants of the ad libitum meal (see Fig. 7.2 for examples). To ensure the satiety measure is sensitive, the time gap between the preload treatment condition and the ad libitum meal must be strictly controlled. In a comprehensive review of preload studies, Almiron-Roig noted that participants tended to be worse at adjusting subsequent food intake as the energy density of the preload increased and as the hiatus between the preload and the test meal became longer (Almiron-Roig et al., 2013). Current best practice suggests there is maximum sensitivity to preload energy differences when this hiatus is kept to between 45 and 60 min and typically no longer than 90 min.

When quantifying satiety in this way it is necessary to measure the energy compensation for the amount consumed as a preload and compare this to a control preload condition. The percentage compensation for energy consumed as a preload can thus be calculated as;

$$\% \text{ Energy compensation} = [(\text{Energy intake}_{\text{control}} - \text{Energy intake}_{\text{treatment}}) / \text{treatment energy content}] \times 100$$

For example, a control treatment could be the current version of the product of interest, whereas the treatment condition could be a reduced-energy version of the same product. An energy compensation score of 100% would indicate perfect compensation for the amount of added or removed energy consumed as a preload treatment (i.e., preload is 200kcal and the ad libitum meal is reduced by 200kcal). However, energy compensation is rarely this accurate and numerous studies have documented the imprecision of short-term human energy intake control (Almiron-Roig et al., 2013; Levitsky, Obarzanek, Mrdjenovic, & Strupp, 2005; McCrickerd, Salleh, & Forde, 2016; Tey, Chia, & Forde, 2016). Changes in acute energy intake are not fully reflected in short-term changes in eating behavior, as when a given day's intake and expenditure are compared there is little association, until these are averaged over longer periods, such as weeks. Therefore small deficits or excesses in energy may not always be detected, as energy balance does not truly equilibrate until after extended periods of time (Hall et al., 2012; Westerterp, 2010). For these reasons, results from short-term studies should be interpreted cautiously. For greater sensitivity and discrimination in satiety responses to different treatments, it is useful

to integrate physiological measures to capture changes in satiety biomarkers in the postmeal period (Allirot et al., 2014). These can provide insights into physiological changes underpinning the subjective experience of satiety and the behavioral satiety measure of later food intake. It is necessary to pair the appropriate experimental paradigm with the time course of suitable metabolic or endocrine correlates when attempting to understand the different physiological mechanisms that underpin eating behavior (Allirot et al., 2012). For example, premeal ghrelin levels are relevant to satiation, whereas postmeal phenomena such as gastric emptying rate; changes in circulating levels of certain gastrointestinal hormones such as glucagon-like-peptide-1 (GLP-1), peptide tyrosine tyrosine (PYY), cholecystokinin (CCK), and polypeptide-P (PP); and suppression of ghrelin are more relevant when exploring satiety (Delzenne et al., 2010). Similarly, across the gastrointestinal endocrine signals for satiety there are differential sensitivities to energy from protein, fat, and carbohydrate content.

Although the distinction between measuring satiation and satiety is clear, there are many aspects of study design that can affect appetite and eating responses to a test meal or treatment and influence outcomes for both sets of measures. These include sensory influences in the test foods, individual differences among participants, and a wide range of variables in the choice of test setup and location. The following section provides some guidance on experimental considerations when setting up an eating trial to measure satiation or satiety.

4. CONSIDERATIONS FOR SELECTING TEST STIMULI AND LOCATION

4.1 Selecting a Meal Paradigm and Test Meal

Whether measuring satiation or satiety, care should be taken to consider the most appropriate test foods to represent the test variables for the specific experimental question. Given the dominance of cognitive influences in subjective eating responses, where possible the underlying macronutrient and energy content of the test stimuli should be manipulated in real foods that mimic normal everyday meal consumption, rather than in model foods that do not reflect the normal eating context. In addition, manipulations of a test meal's energy or macronutrient content can be made covertly or overtly, where the subject is made aware of the differences. This awareness can influence the subjects' eating response, and so care must be taken when deciding whether this awareness will unduly influence the outcome of the trial (Stubbs et al., 2001).

The number and nature of test foods provided, their predominant sensory character and intensity, and their palatability are hugely influential in the calories consumed to satiation. When selecting the food for a test meal it is best to fix all of the other parameters of the meal and vary the test meal only on the property being tested. This requires strict control of the test food properties,

including the food's sensory and hedonic properties, as strongly flavored or highly liked foods should be avoided in case they stimulate intake independently (Yeomans, 1998; Yeomans, Lee, Gray, & French, 2001). Palatability has been shown to influence the amount of energy consumed to satiation but not influence satiety (De Graaf et al., 1999). Often, other overlooked food properties can also influence the rate and amount consumed, including food texture (de Graaf, 2012) and the impact this has on eating rate (Forde, van Kuijk, Thaler, de Graaf, & Martin, 2013a) and overall energy intake (Bolhuis et al., 2014; Forde, van Kuijk, Thaler, de Graaf, & Martin, 2013b). A food's sensory properties play a functional role in moderating the way it is eaten and influence the total amount of food consumed within an ad libitum meal (Forde, 2016; Green, Wales, Lawton, & Blundell, 2000). For example, a longer orosensory duration and stronger sensory intensity are associated with faster onset of satiation (Bolhuis, Lakemond, de Wijk, Luning, & de Graaf, 2011; McCrickerd & Forde, 2016). Unless the study aims to explore the impact of sensory properties on energy intake, every effort should be made to avoid explicit sensory cues that signal differences in energy content, food textures that strongly influence eating microstructure, and strong flavors that will polarize preferences across participants or become aversive following repeated exposure.

Satiation and satiety studies have the option of using either a single-course ad libitum meal or a buffet-style ad libitum meal paradigm to measure intake. When the goal of the trial is the measurement of total amount of energy consumed, it is recommended to use the single-course meal, as it is a reproducible and reliable measure of self-selected energy intake and normal eating behavior for the given test meal (Gregersen et al., 2008).

4.2 Single-Course Meal Paradigm

The single-course test meal can be used to measure both satiation (energy consumed to fullness) and later energy intake following a period of satiety (Fig. 7.2(a)–(d)). The single-course paradigm is the most widely used approach to quantifying the food consumed to fullness in response to the variable that is being tested. An advantage of the single-course meal is that it is easy to implement and interpret and enables a clear measure of quantitative intake to fullness that is well controlled for biases. A limitation of the single-course test meal approach is that when restricting consumption to a single meal item, the focus is only on quantity consumed and not on food choice, thus poorly reflecting a real-life meal where multiple food items are available and can be freely consumed (Chapelot, Blundell, & Bellisle, 2013; Hill, Rogers, & Blundell, 1995). Similarly there is a natural decline in food pleasantness associated with the continued consumption of the same food item that has been termed “sensory-specific satiety,” and the relative contribution of this to measured satiation cannot be accounted for separately in the results, as this may vary from person to person and as a function of the sensory properties of the food items served.

In selecting the meal's predominant sensory properties, most ad libitum meals tend to be savory, though research has indicated that there is no difference in the onset of satiation for equally sweet or savory ad libitum meals (Griffioen-Roose, Mars, Finlayson, Blundell, & de Graaf, 2009). The food should have a medium energy density (1–1.5 kcal/g), as small differences in intake of a very energy dense meal may unrealistically overestimate the effect on total energy consumed. For the same reason, the food chosen should not be unusually high in a specific macronutrient, as high-fat meals have been found to inflate energy intake and do not generalize to everyday meal occasions (Green et al., 2000). The food chosen should not be unfamiliar, as intake may reflect a neophobic response rather than the true motivation to consume.

In addition to the sensory properties, food variety ought to be limited during an ad libitum test meal and held constant across all test sessions so as not to confound comparison of energy intakes and encourage additional intake due to “variety effects” (Hetherington, Foster, Newman, Anderson, & Norton, 2006). The foods chosen should also be appropriate for the consumption context under investigation, such as serving breakfast foods at a breakfast ad libitum trial and savory foods for lunch (Cardello & Schutz, 1996). One requirement is that participants receive an ample serving of food at the beginning of an ad libitum eating trial to prevent them from cognitively estimating how much food they plan to consume at the outset of the meal. The term “ad libitum” refers to providing participants with free access to the food being measured and ensuring there is always a surplus of food served, meaning more food than a participant would be expected to consume. This is typically completed through the provision of a large portion of the test meal (800–1000 g) with the instruction that more is available if required. The reason for this is to reduce the risk of external cues that may influence some individuals' eating behavior, such as plate cleaning, where the participant is reliant on visual cues and not appetite motivational state when deciding to cease consumption (Fay et al., 2011; Hinton et al., 2013; Wansink & Johnson, 2015). One example of the overreliance on visual cues is the refilling soup bowl study, in which participants ate an average of 73% more energy when their bowls were covertly refilled, and yet reported not feeling significantly fuller (Wansink, Painter, & North, 2005). The same visual bias has also been found to influence satiety (Brunstrom et al., 2012). A criticism of serving large single-course ad libitum meals is that they are likely to tend to overestimate the amount of food someone would typically choose to consume because of the portion-size effect, whereby normal intake is inflated when larger portions are served (Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Rolls, Roe, Meengs, & Wall, 2004). Concerns have also been raised about using amorphous versus unit foods for the ad libitum test meals, as distinct food items presented as units may be subject to certain unit biases whereby participants tend to consume the whole item, rather than eating until comfortably full (Geier, Rozin, & Doros, 2006). Often this is dealt with by cutting larger units into smaller or more homogeneous sizes such as sandwiches that are cut into smaller

pieces (Rolls et al., 2004). Despite suggested limitations, the single-course ad libitum test meal provides a reliable and reproducible measure of quantitative energy intake from a single meal when correctly applied (Arvaniti et al., 2000; Gregersen et al., 2008).

4.3 Buffet Meal Paradigm

An alternative is to present a buffet-style meal where multiple foods are presented in close proximity to participants and they can freely choose the type and amount of food they would like to consume (Allirot et al., 2012). When setting up a buffet-style meal, all items should be clearly identifiable and served in an individual bowl and subjects should be served a surplus that is more than they would be expected to consume. The main advantage of the buffet meal paradigm is the additional insight into the qualitative aspect of food choice as well as the quantitative information on energy intake during the same meal. Through careful selection of the test foods, the buffet meal makes it possible to study macronutrient selection under specific conditions and facilitate an understanding of the interplay between liking and homeostatic need state. Examples include studying macronutrient and energy selection following exercise (King & Blundell, 1995), or when testing whether food choice and intake are manipulated when participants are significantly protein depleted (Griffioen-Roose et al., 2012).

Buffet-style meals add an additional parameter in food choice and selection, which may not reflect the homeostatic drive to eat but rather is motivated by a desire to consume a variety of hedonically appealing foods independent of need state (liking and wanting) (Berridge, 1996). The time taken to select foods from the buffet has also previously been reported as an indication of participants' motivation to eat (King, Burley, & Blundell, 1994) and a measure of their "food wanting." The buffet meal confounds the direct causal measurement of food intake based on appetite motivational state alone, by adding additional dimensions to the measure. The broader inference derived has significant limitations in that conclusions regarding food choice and preference can be drawn only on the foods presented (Blundell et al., 2010; Chapelot et al., 2013). Strict control must be placed on the selection of foods and their presentation, as outcomes can be unintentionally biased by the arbitrary nature of the foods provided or even the proximity of the foods on the table in front of the participants. Energy intake can also be unduly influenced by differences in food temperature, energy density, or salient sensory properties. Buffet lunch meals also cause problems for repeated-measures (crossover) designs, as subjects tend to spontaneously choose different test foods across successive test days, which may confound interpretation of energy and macronutrient intakes as they relate to the test variables (Kissileff, 1985). In summary the single-course meal is appropriate when the focus is on measuring quantitative intake of energy or macronutrients and is often preferred when studying the biological determinants of food intake within

and between meals (Karl, Young, & Montain, 2011). The buffet meal is suitable when studying food choice and intake simultaneously for specific experimental questions, but should be used judiciously as it is prone to greater variability, and reproducibility of the findings can be strongly influenced by the foods chosen.

Data from eating trials can only be as good as the rigor of the experimental paradigm selected for the test question being addressed, the test variables selected (i.e., foods or beverages), and the participants recruited to complete the tasks. Food intake trials are indirect measures that rely on control and consistency under the test conditions for inferences to be successfully drawn on the reasons for the initiation or cessation of an eating event. In addition to the selection of the appropriate test food and paradigm, the measurement of satiation requires consideration of other influences of food intake that can significantly influence the outcomes. These include the test location, instructions, participants, and design or setup. These are discussed in more detail next.

4.4 Measuring Food Intake in a Laboratory

Food intake trials can be conducted in an ingestive behavior laboratory or in a free living test environment. One test environment may be more or less suitable than another, depending on the goals of the trial being completed, as there is a trade-off to be made between control and accuracy of the measures compared to the ecological validity of the consumption context. These decisions represent the equilibrium between internal and external validity of the measures collected, and rather than one correct approach, a balance needs to be struck between the two when choosing the appropriate test location for a specific study. Laboratory studies enable direct comparison of specific factors on appetite and eating behaviors, and conclusions can be drawn from a trial only if there is sufficient control in the accuracy and precision of ratings and food intake measures taken during the trial. Every effort should be made to remove food-related cues from the test environment and standardize the test space for noises, clocks, smells, and potential distractions. When setting up a test to measure food intake, it is important to consider a range of factors that can significantly influence or bias the amount of energy consumed until fullness. These include environmental cues within the test room such as plate size, choice of utensils, visual cues that may stimulate appetite, background odors and noises, food label information, and consistency of the food stimuli. Every effort should be made to keep these factors controlled and constant from one session to the next to ensure comparable experimental conditions across stimuli.

Confidence in the results will be enhanced by a longer measurement period, as acute eating studies cannot be generalized to accurately represent habitual dietary energy intake behavior. Additional food intake measures can be collected away from the laboratory through the use of food diaries, though these tend to be cumbersome to complete and analyze and are regarded as limited because of widespread response biases and underreporting (Livingstone et al.,

2000). When comparing eating trials conducted in a laboratory and in free living environments the differences extend beyond eating context, as different methods of data collection are applied to studies conducted in each setting. In addition, in recent years the eating environment itself has become a test variable, as many studies attempt to understand social and environmental factors that influence food intake (Robinson, Tobias, Shaw, Freeman, & Higgs, 2011; Stroebele & de Castro, 2004).

4.5 Remote Food Intake Data Collection

In addition to collecting food intake data in the laboratory it is also possible to gather estimates of energy intake remotely. Although there have been advances in the remote collection of dietary data and some efforts to validate meal photographs with nutritional information, remote data collection for energy intake is still widely regarded as inaccurate and at best an estimate of energy intake (Martin et al., 2009). Food purchase behavior has been tracked through food disappearance data, shopper loyalty cards, and scanner information (Mathias, Ng, & Popkin, 2015; Smith, Ng, & Popkin, 2014), and whereas these data may provide macro-trends in population intake behaviors, they cannot provide reliable information on intake or motivational states and are unsuitable for studying satiation and satiety. When setting up an eating trial, there is an important trade-off to be made between the highly controlled internal validity of the laboratory and the lower control higher external validity of the external environment. Current methods for measuring eating behaviors and recording food intake away from the laboratory are less accurate than laboratory-based methods and the preference remains to study appetite and food intake in controlled laboratory trials designed to achieve representative data for causal inference (Gibbons et al., 2014). Short-term records of food intake can be recorded away from the laboratory to capture an estimate of the quantity and timing of additional food intake later the same day of an experimental treatment. An example is the use of food diaries to collect later snack or evening meal intake following the consumption of a test meal (for examples see McCrickerd et al., 2016; Tey et al., 2016). These food diaries can then be collected at the next session and entered by hand into diet analysis software to estimate the kilocalories and macronutrient intake away from the laboratory, and are added to the data for total energy consumption over the course of a test treatment day.

5. GENERAL GUIDELINES FOR SETTING UP A SATIATION OR SATIETY TEST

5.1 Selecting the Appropriate Test Participants

In addition to thoughtful consideration of food stimulus selection, equal attention should be given to the selection of a test population appropriately screened to ensure they are representative participants for the test being conducted. If the

emphasis in the trial is to study the satiating properties of a new formulation or compare one product to another then it is often better to restrict the variability in the test population and recruit a homogeneous group of subjects (i.e., lean healthy males, within a narrow age range, and frequent users of the product). This would be the case when using a “satiety panel” to function much like a trained sensory panel, but to compare the filling properties of different foods from the same category (Lesdéma et al., 2016). A satiety panel comprising 15–18 subjects could be recruited to make satiety comparisons across products. Subjects tend to be matched for criteria that would be expected to influence food intake and subsequent feelings of hunger and fullness, such as body weight, gender, appetitive traits, and eating behaviors such as dietary restraint or usage of the product category. If the goal of the trial is to understand the consistency of the satiating properties of a product across a wide population, then the test subjects themselves become a focus of the eating trial and differences in the amount consumed to fullness or their subjective impressions of fullness over time can be compared across a large and diverse cohort. For population-wide claims it is first important to consider whether the eating trial has been carried out in a group representative of the population group for which the product is intended. Studies in groups of specific populations beyond the general population (e.g., elderly subjects or subjects with a specific disease) must be assessed on a case-by-case basis for the extent to which the established satiety response can be extrapolated from the study group to the target group. Population-wide claims require specific power calculations to identify the appropriate sample population size and can be further enhanced through replication of the eating response of subjects to enable comparison of the satiating responses for subgroups (i.e., males and females, lean and obese, or subjects with different eating behavioral traits for the same foods).

5.2 Standardizing the Test Instructions to Participants

Seemingly straightforward differences in the instructions given to subjects at the beginning of a test meal can sometimes have unintended consequences on eating trial outcomes. For example, changing instructions from “eat until comfortably full” to “eat your normal lunchtime meal” can alter the eating goals of the subject and conceal subtle underlying differences in need state and change the outcome of the trial. Specific attention should be given to ensuring that the overall goals of the trial are protected from influences that will prevent comparison across the variables of interest post hoc. Similarly, making subjects aware of the time they will have to wait until their next eating event has been shown to significantly influence the amount of food consumed during an ad libitum test meal (De Graaf et al., 1999). Most trials fix the amount of time subjects are given to consume the test meal, rather than leaving it open ended for participants to decide, as this can also lead to response biases if subjects feel obliged to keep consuming until instructed to stop by the test instructor. Participants

should be given a sufficient amount of time to eat a test meal and this should match the usual time needed to eat a meal of this nature.

5.3 Test Design and Power Calculation

When considering the outcomes and experimental comparison you would like to make in the data collected, there is a choice to be made between measuring differences between test products and treatments or differences between an individual's satiety responses. For studies that aim to explore individual differences in satiety response, the number of treatments should be limited, whereas a large number of participants are required (Appleton, Martins, & Morgan, 2011). Between groups (Forde et al., 2013b) and incomplete block designs (Viskaal-van Dongen, Kok, & de Graaf, 2011) have been used in the past, but owing to large interindividual variation in the study population, it is preferable that each subject receives all treatments in a repeated-measures/crossover design. With between-groups designs large numbers are often required to average out individual differences, and differences in food intake can be compared only at a group level. For preload satiety studies, some comparisons have highlighted differences in the sensitivity of crossover versus between-groups designs and found that crossover designs tend to underestimate energy compensation in satiety trials on sweeteners (Gadah, Brunstrom, & Rogers, 2016). For studies that aim to compare the satiating properties of foods the optimal approach is a repeated-measures design in which all subjects receive all treatments at least once and can act as their own control when comparing the effects of a treatment on hunger, fullness, and subsequent amount consumed. For these studies there is no published optimal number of treatments, but often it is best to keep the treatments to no more than five or six to avoid subject fatigue, dropouts, and potential learning from repeated exposure (Blundell et al., 2010). Each study should be accompanied by its own power calculation to ensure sufficient power across experimental treatments where the sensitivity of the test measures is determined by the measure being used (i.e., intake from a test meal is more sensitive compared to estimating intake from a food diary). Studies of this nature typically require no fewer than 20–25 subjects and often start with more ($n=30$) to ensure sufficient comparisons can still be made should some subjects drop out. The study design should maximize the control and accuracy of the comparisons of interest within the specificities of the test population and treatments. Where possible, the sample size should be guided by power calculations based on previous measures of sensitivity and variance for a similar treatment and test population. The sensitivity required for the measures applied in an eating trial are influenced by the degree of difference in the food stimuli being tested, the homogeneity of the test population, and the number of treatments under investigation. For satiety trials, the degree of difference in the energy content of the treatments and the time difference between the preload and the test meal will also influence the sensitivity of the measures. Sensitivity to differences in

the energy content of a preload decreases progressively the longer the hiatus between preload and test meal. Best practice would be to power the study to cover the least sensitive measure, ensuring all other measures are adequately covered.

6. ADDITIONAL MEASURES FROM SATIETY AND SATIATION TRIALS

6.1 Eating Microstructure and Food Intake

In addition to understanding how much food is consumed to satiation, it is also of value to study the kinetics of food intake during a meal to track the temporal development of satiation as it relates to eating patterns. These behaviors have been termed the “microstructural patterns of eating” and include a description of the total number of bites, average bite size, bite rate, chews per bite, and average eating rate associated with eating different foods or as measured at different phases of the meal. Objective approaches for studying eating microstructure have been used for nearly 40 years and began with the development of the “Edogram” (Bellisle & Le Magnen, 1980) and later the “universal eating pattern monitor” (Kissileff, Klingsberg, & van Itallie, 1980). In both cases it is possible to track eating throughout the meal by measuring the changing weight of the plate as food is removed, using an electronic balance that is concealed within the table. Using these data it is possible to plot cumulative intake curves of grams consumed per minute, the slope of which is a measure of a participant’s eating rate at different phases of the meal. Specific algorithms have been developed to compare cumulative intake curves across different types of participants and foods (Kissileff, Thornton, & Becker, 1982; Westerterp-Plantenga, 2000). It is also possible to track changes in appetite ratings sequentially throughout the meal and relate this back to the microstructure of eating to track whether changes in motivation to eat are reflected in certain eating styles (Yeomans, 2000). Using these approaches it is possible to track the patterns of intake within a test meal, or study the psychopathology of disordered eating behaviors (Ioakimidis et al., 2011; Zandian, Ioakimidis, Bergh, Brodin, & Södersten, 2009). In the latter case, an understanding of disordered eating microstructure has led to the development of intervention strategies based on eating rates to enhance the regulation of energy intake (Ford et al., 2010). Research has shown that participant awareness that their intake was being observed made little difference to either the amount consumed or the eating microstructure during a test meal (Robinson, Kersbergen, Brunstrom, & Field, 2014; Thomas, Dourish, & Higgs, 2013, 2015). One drawback with ingestive pattern monitors for tracking eating is that when using the covert approach up to 25% of the data can be lost because of errors such as leaving cutlery on the plate or on the balance (Thomas et al., 2015). An alternative approach is to use behavioral coding of video recordings of subjects eating during an ad libitum meal, and previous

research has highlighted the validity of behavioral coding analysis of video recordings for use in quantifying eating behavior (Hennequin, Allison, Veyrune, Faye, & Peyron, 2005). These approaches provide important insights into the motivational state of subjects and individual differences in eating behaviors within a test meal that enable post hoc explanations of differences in energy intake or feelings of fullness (Ferriday et al., 2016). Using this approach it was possible for Bolhuis and colleagues to understand the impact of harder food textures on average bite size, orosensory exposure time, and eating rate that led to a 13% reduction in ad libitum food intake at a lunchtime meal (Bolhuis et al., 2014). Behavioral coding of eating behaviors has the advantage of being noninvasive, reliable, and cost effective, and can provide important insights into the microstructural patterns of eating within a meal to support satiation and satiety measures.

6.2 Measuring Expected Satiety

The starting point for all of the aforementioned satiation and satiety methods is the beginning of the meal, but many of the important calorie intake decisions that control food intake are often made before a meal begins, at the point of selecting the food (energy density) and the portion (energy content). Most people tend to consume all of the food they select to eat and “plate clean” (92%–97%), relying on this visual cue rather than physiological feedback within the meal to determine the amount of energy to consume (Wansink & Johnson, 2015). Similarly, we are rarely surprised by how full or hungry we feel at the end of the meal, and research indicates a certain degree of premeal planning occurs in which we mentally budget the amount of food to consume, to alleviate hunger for a desired period (Brunstrom, 2014; Fay et al., 2011). We have a broad experience of the filling properties of a wide range of different foods and this largely determines the portion we select for a given meal (Brunstrom & Rogers, 2009). Significant advances have been made in our understanding of the cognitive processes that inform food and portion selection before the meal and our understanding of the relationship between portion choice and postmeal satiety (Brunstrom, Shakeshaft, & Scott-Samuel, 2008). Much of this research has focused on the development of approaches to quantify consumer expectations of the fullness (expected satiation) and the absence of hunger between meals (expected satiety) that different food and beverage products are expected to deliver (Forde, Almiron-Roig, & Brunstrom, 2015). These perceptions can be reproducibly measured, can discriminate between foods and beverages, and have been shown to predict actual portion selection and intake at a later meal (Forde, Chia-Ming, Lim, Sim, Cheon, 2016; Wilkinson et al., 2012). A better understanding of the food properties that moderate expectations of fullness and satiety can provide valuable insights into human energy selection and intake behaviors and complement the satiation and satiety test meal approaches outlined earlier. Although these techniques cannot replace the sensitivity of

experimentally measured food intake recorded in human eating trials, they make it possible to compare a wide range of food product variables for the impact they are likely to have on portion selection and satiety expectations. An example is a 2015 study that applied these measures to gain a better understanding of how protein addition influenced expectations of fullness across a series of yogurt samples (Morell, Piqueras-Fiszman, Hernando, & Fiszman, 2015). In this regard, expected satiety methods complement traditional satiation and satiety eating trials by enhancing our understanding of the motivations behind energy selection and intake, and by providing guidance on the appropriate portion size required to satisfy hunger.

7. LINKING BEHAVIORAL MEASURES OF SATIETY TO PHYSIOLOGICAL CONSEQUENCES OF FOOD INTAKE

This chapter describes the subjective measurement of appetite and energy intake to satiation and subsequent quantification of satiety. These subjective feelings and behaviors are causally driven by changes in our neural, endocrine, gastric, and gastrointestinal responses to the foods consumed. It is possible to connect physiological measures of satiation and satiety with the eating trial measures outlined earlier. These physiological biomarkers are typically collected using repeated-measures designs whereby each participant can act as his or her own control and changes from baseline across treatments can be compared for each individual. When quantifying the postingestive physiological response to a test food or beverage the changes in concentration of gastric or serum biomarkers will be dose-dependent, so it is important to standardize the portion served for the test food for consistency of comparison. The most commonly reported physiological measures tend to be signals from the stomach and endocrine signals from both the stomach and the gastrointestinal (GI) tract that act directly on the brain or peripherally on the central nervous system (Cummings & Overduin, 2007). These targets include changes in gastric distention, gastric emptying, and secretion of endocrine peptides in the stomach and GI tract. Gastric distention and emptying can be measured using ultrasonography or MRI and by the rate of paracetamol absorption, which is used for liquids. These measures increase respondent burden and tend to be conducted in parallel to rather than within eating trials, to compare gastric distention and rate of gastric emptying across several foods. There are also a number of widely studied biochemical targets that are linked to the onset and decay of satiation and satiety, and these are predominantly peptide hormones that either stimulate appetite (orexigenic) or suppress appetite (anorexic). These “satiety peptides” are secreted into the stomach, ileum, and GI tract and can act either centrally in brain regions such as the hypothalamus or peripherally to mediate neuron activity, or both. The chosen biomarker of satiation and satiety needs to be reliable, sensitive, specific, and predictive of appetite feelings and food intake (de Graaf, Blom, Smeets, Stafleu, Hendriks, 2004). The most common targets include the appetite-stimulating

hormone ghrelin (orexigenic) and the anorexic hormones CCK, GLP-1, and PYY (Delzenne et al., 2010). PP has also been studied in relation to the sensory and nutrient content of beverages (Yeomans, Re, Wickham, Lundholm, & Chambers, 2016). The glycemic response to food intake can also be profiled by measuring changes in circulating blood glucose and secretion of the peptide hormone insulin, and meal initiation has been linked to declines in blood glucose (Kovacs et al., 2002).

Serum concentrations of the target satiety peptide are collected in tandem with food intake and satiety ratings using sequential blood draws at time points that overlap with subjective appetite ratings (see Yeomans et al., 2016, for an example). These peptides differ in their detection sensitivity and time course and are secreted differentially in response to different foods and sensory stimuli. The choice of which peptide target to measure is contingent on the research question being asked and the macronutrient content of the foods under investigation, and studies have suggested combinations of peptides for maximum sensitivity (Mars et al., 2012). Measuring these peptides makes it possible to explore aspects of the mechanism of satiation onset and satiety duration by tracking serum concentration changes for the chosen target peptides before, during, and after a test meal (Delzenne et al., 2010). These approaches allow comparing across test foods or new formulations, by tracking the same appetite and GI biomarkers under the same conditions across multiple test sessions, to identify the specific endocrine or gastric signals associated with the perceived differences in fullness. These physiological measures of satiety provide powerful insights into the mechanism underpinning differences in the satiety experience across foods. However, reproducible results from these clinical measures require invasive techniques such as cannulation for repeated blood draws, and the test procedure often adds further restrictions around eating occasions to aid reproducibility and discrimination. These tighter restrictions may lead to a loss of ecological validity and may not truly reflect consumers' real-life experiences with a test meal. For research purposes these controlled clinical approaches to understanding appetite regulation significantly aid our understanding of the neuroendocrine regulation of food intake, and provide detailed information on the cephalic, gastric, and GI impact of appetite.

8. CONCLUDING REMARKS

In recent years there has been an increased focus on understanding the satiating properties of foods and beverages and on developing approaches to communicate enhanced satiety as a functional benefit to an increasingly health-conscious consumer. Claims on functional benefits such as enhanced satiety or “feeling fuller for longer” are tightly regulated and must be supported with robust data that demonstrate a sustained effect in human eating trials (Halford & Harrold, 2012; Hetherington et al., 2013). Among food researchers there is an interest in using food formulation, structure, oral processing, and sensory properties

to enhance the satiating power of foods per kilocalorie consumed (Campbell, Wagoner, & Foegeding, 2016; Chambers, Mccrickerd, & Yeomans, 2015). There is an increasing awareness among food developers and consumer scientists that increasing the hedonic appeal of a food is no longer enough to sustain acceptance, and beyond the role in driving food liking, a food's sensory properties can strongly influence food choice and energy intake decisions (McCrickerd & Forde, 2016). The important distinction between the measurement of satiation (fullness) and that of satiety (fullness over time) is critical when considering the experimental question being investigated in an eating trial, as each requires specific controls and measurement criteria. Accurately quantifying satiation and satiety sensations is central to progressing our understanding of the human psychobiology of eating behavior, energy selection, and intake. The techniques described in this chapter provide a framework for designing trials that enable the comparison of feelings of satiation and satiety for different products and across populations. For all such trials, consideration should be given to the test stimuli and the variables they represent and the test population from whom measures are derived, and care should be taken to design an approach that maximizes the sensitivity of comparison for the sensations of interest. Increasingly it will be necessary to go beyond simply tasting foods for sensory or hedonic appraisal, to understanding the development of fullness feelings within the product experience and their impact on energy intake regulation from meal to meal.

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Chapter 8

Methodological Approaches for Measuring Consumer-Perceived Well-Being in a Food-Related Context

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1. INTRODUCTION

The sensory characteristics of products have long been recognized as one of the most important determinants of consumer choice and the success of products in the marketplace (Tuorila, 2007). However, other aspects of food consumption also play a relevant role in consumer’s decision-making process (Köster, 2009). For this reason, the need to consider a more holistic view of consumer perception has been recognized (Andersen & Hyldig, 2015; Meiselman, 2013, 2016).

Well-being has become a relevant research topic in various disciplines, such as psychology, economy, sociology, and medicine, and has been recognized as a key concept for the development of innovative and more successful public

policies (Cronin de Chavez, Backett-Milburn, Parry, & Platt, 2005; McMahon, Williams, & Tapsell, 2010). This concept has also gained growing attention in sensory and consumer science and has been claimed to be one of the most relevant topics for the future of the field (Meiselman, 2013, 2016).

Well-being is one of the ultimate end-state conditions that people pursue in their life (Diener, Scollon, & Lucas, 2003). People's choices and lifestyle decisions have been claimed to be oriented to achieve well-being (Angner, 2009). Therefore, a better understanding of how foods influence well-being can contribute to the understanding of consumer food choices and to the development of successful strategies for encouraging healthful eating patterns (McMahon et al., 2010). In addition, the consideration of consumer-perceived well-being during new product development may enable product differentiation and, consequently, increase the chances of success in the market.

2. WHAT IS WELL-BEING?

Well-being is a complex term that lacks a unique definition (Dodge, Daly, Huyton, & Sanders, 2012). Two main traditional approaches to defining well-being can be found in the literature: hedonic and eudaemonic (Ryan & Deci, 2001). According to the hedonic approach, well-being is closely related to pleasure and happiness, involving the evaluation of the degree to which a person experiences positive moods and emotions, and does not experience negative moods and emotions (Diener et al., 2003; Kahneman, Diener, & Schwarz, 1999). The eudaemonic approach states that well-being occurs when people's lives are congruent with their values (Waterman, 1993) or when they can fulfill their true potential (Ryff & Singer, 2000). However, several authors have argued that well-being is probably best conceived as a complex and multidimensional concept that includes aspects from both the hedonic and the eudaemonic approaches (Ryan & Deci, 2001). In this sense, McGillivray and Clarke (2006) define well-being as a multidimensional subjective evaluation of a person's life, which includes both cognitive and affective aspects, whereas the Merriam-Webster dictionary defines well-being as "the state of being happy, healthy, or successful" (Merriam-Webster, 2004).

Well-being is closely related to other constructs, such as health, wellness, and quality of life. Although well-being is included in the definition of health of the World Health Organization (i.e., health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity; WHO, 1946), it is commonly used as a more holistic concept that goes beyond physical health to dismiss the medical model of managing illness (McMahon et al., 2010). Regarding the terms wellness and quality of life, they are normally used interchangeably in the literature, with the term well-being being used to refer to a holistic evaluation of a person's life (Miller & Foster, 2010).

Despite the lack of a consensual and standard definition of well-being, agreement on the fact that it is a complex multidimensional construct exists (McGillivray & Clarke, 2006; Miller & Foster, 2010). Diener et al. (2003) claimed that well-being has a hierarchical structure composed of four main dimensions: pleasant emotions, negative emotions, global life judgments, and satisfaction with specific domains. According to these authors, subjective well-being involves an affective and a cognitive evaluation of a person's life considering both a global perspective and specific domains or aspects of life, e.g., health, work, social relationships, and money. Hettler (1984) also refers to the multidimensional nature of well-being by defining six dimensions that relate to one another: physical, intellectual, social, emotional, occupational, and spiritual. Meanwhile, Veenhoven (2000) proposed four dimensions of well-being: livability of the environment (good living conditions), utility of life (achievement of higher values), life ability of the person (ability to cope with life), and appreciation of life (related to subjective well-being).

Despite the fact that several dimensions have been included in the conceptualization of well-being, the most common dimensions are physical, psychological/emotional, social, spiritual, and intellectual (Roscoe, 2009). The physical dimension is closely related to physical health, involving body functioning, absence of illness and disease, physical activity, fitness, and nutrition. Meanwhile, intellectual well-being involves the degree to which people engage in creative and stimulating activities, as well as the use of resources to expand and share knowledge, and develop skills and abilities, and engagement in critical thinking. Psychological and emotional well-being has been conceptualized as the presence of positive emotions, absence of negative emotions, as well as awareness and control of feelings. Social well-being is related to the quantity and quality of social interactions with other people and the community. Finally, spiritual well-being is related to broad personal values and beliefs, such as meaning and purpose in life, ethics, and sense of selflessness.

Ares, de Saldamando, Giménez, and Deliza (2014) and Ares et al. (2015) explored how consumers conceptualize well-being in different countries and concluded that it is perceived as a multidimensional construct related to psychological aspects, particularly positive moods and emotions, physical health, a global evaluation of life, and satisfaction with specific aspects of life. According to the authors, psychological aspects were the most relevant to consumers' conceptualization of well-being, followed by physical health.

3. CONCEPTUALIZATION OF WELL-BEING IN A FOOD-RELATED CONTEXT

Foods have several functions in our lives: they provide the nutrients necessary for body functioning, influence our moods and emotions, and have symbolic,

esthetic, social, and moral significance (Macht, 2008; Rozin, 2005). For this reason, foods are expected to influence the various dimensions of perceived well-being.

Ares et al. (2014; 2015) explored how consumers in five countries (Brazil, France, Portugal, Spain, and Uruguay) conceptualized the influence of foods on their well-being. According to these authors, consumers referred to the effects of foods on their physical health, emotions, and intellectual performance, as well as their social life. Within the physical health dimension, consumers indicated that foods influence their well-being by improving their body functioning and contributing to the prevention of noncommunicable diseases, such as obesity and cancer. Regarding the emotional aspects of well-being, consumers stressed the relationship between food and pleasure, mood, satisfaction, happiness, joy, anxiety, calm, energy, and vitality, among others. Finally, consumers also referred to the influence of food on social well-being through their contribution to social relationships. Although psychological aspects were the most salient in consumers' conceptualization of well-being, in a food-related context physical health was more relevant.

Guillemin et al. (2016) proposed a conceptual base for food-related well-being based on responses from focus groups consisting of 198 French consumers. These authors identified several concepts for food-related well-being, which were separated into two main domains: pleasure and health. As shown in Fig. 8.1, the conceptual model developed by Guillemin et al. (2016) included aspects related to physical health, emotions, and social aspects of well-being.

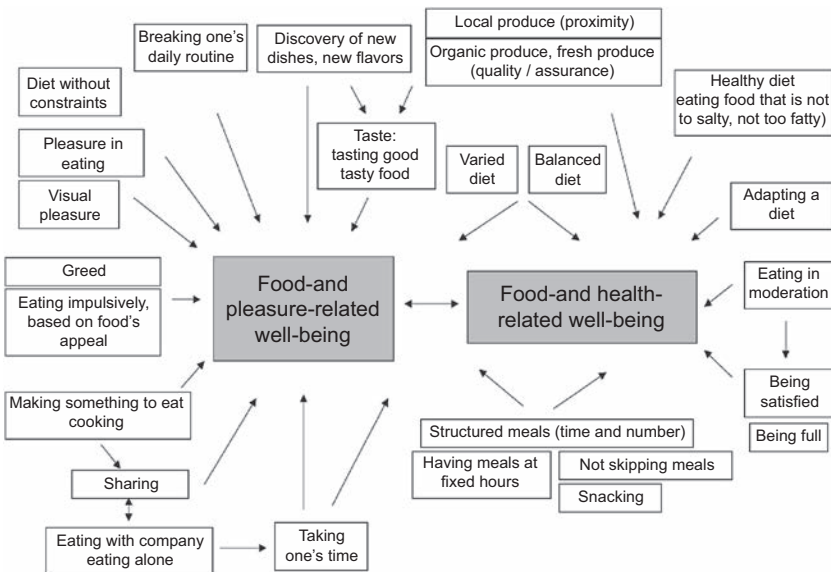


FIGURE 8.1 Conceptual model of food-related well-being developed by Guillemin et al. (2016).

4. METHODOLOGICAL APPROACHES TO MEASURING WELL-BEING IN A FOOD-RELATED CONTEXT

Well-being is a subjective concept, based on people's evaluation of different aspects of their lives. For this reason, well-being measurements should rely on consumer perception (WHO Regional Office for Europe, 2012). Given the expertise of sensory and consumer scientists with subjective measurements, they are expected to play a key role in the development, validation, and use of methodological approaches to evaluate well-being perception (Meiselman, 2016).

Three main approaches have been used to assess the influence of food on well-being. The first approach involves the use of general subjective well-being measures and their correlation with food-related data, such as nutritional status or eating patterns (e.g., Chanfreau et al., 2008). More recently, two approaches based on specific questionnaires to measure well-being in a food-related context have been developed. The first group of questionnaires enables one to measure consumers' perception of their own food-related well-being (Guillemin et al., 2016), whereas the second group is focused on consumers' perception of the influence of foods on different aspects of their well-being (e.g., King et al., 2015). In the following subsections each of these three methodological approaches is discussed and some examples of application are described.

4.1 Subjective Well-Being

A wide range of methodological approaches to measuring subjective well-being has been developed in different fields (WHO Regional Office for Europe, 2012). These approaches involve several different questions to explore consumers' global evaluation of their subjective well-being and/or their perception of specific domains of well-being.

The World Health Organization (WHO) has developed several well-being scales in the context of primary health for evaluating treatments and interventions (WHO Regional Office for Europe, 1998). The first WHO well-being questionnaire was composed of 28 items, which enabled assessment of positive and negative feelings related to well-being (Bech, 2012). Subsequent studies on the dimensionality of the questionnaire led to the development of shortened versions, such as the WHO-10 or the WHO-5 well-being questionnaire. The WHO-5 well-being scale is composed of five statements related to positive feelings that provide a unidimensional evaluation of well-being (Table 8.1). For each statement, respondents are asked to use a 6-point scale to describe how they have been feeling over the past 2 weeks. The scale varies as follows: all the time (5), most of the time (4), more than half of the time (3), less than half of the time (2), some of the time (1), and at no time (0) (WHO Regional Office for Europe, 1998). Consumer-perceived well-being is calculated by summing the responses to the five items and converting the sum to a standardized percentage

TABLE 8.1 Items^a Included in WHO-5 Well-Being Scale (WHO Regional Office for Europe, 1998)

Item
I have felt cheerful and in good spirits.
I have felt calm and relaxed.
I have felt active and vigorous.
I woke up feeling fresh and rested.
My daily life has been filled with things that interest me.
<i>^aEvaluated on a 6-point scale comprising all the time (5), most of the time (4), more than half of the time (3), less than half of the time (2), some of the time (1), and at no time (0).</i>

score. The WHO-5 has been validated in several studies conducted in different countries and is one of the most popular questionnaires in the health field (Bech, 2012).

The Personal Well-Being Index is another instrument, which provides a multidimensional measure of subjective well-being (International Wellbeing Group, 2006). The Personal Well-Being Index comprises eight items that cover different domains of life (standard of living, personal health, achievement in life, personal relationships, personal safety, community connectedness, future security, and spirituality/religion) and an item that provides a global evaluation of “life as a whole” (Table 8.2). Participants have to rate each of the items using an 11-point scale ranging from no satisfaction at all (0) to completely satisfied (10).

The satisfaction with life scale, developed by Diener, Emmons, Larsen, and Griffin (1985), consists of five items, which do not intend to measure respondents’ perception of different domains of well-being, but rather to obtain an overall cognitive judgment of a person’s life (Table 8.3). Respondents have to rate their degree of agreement with each of the items using 7-point Likert scales, which are then summed up to obtain a global well-being score. This scale has been validated in different countries and languages and has been used across different disciplines (Arrindell, Heesink, & Feij, 1999; Blais, Vallerand, Pelletier, & Briere, 1989; Diener & Ryan, 2009; Gouveia, Milfont, da Fonseca, & Coelho, 2009; Sachs, 2004).

Correlations between general measures of subjective well-being have been reported in several studies. Chanfreau et al. (2008) reported that subjective well-being was positively correlated with consumption frequency of fruits and vegetables in adults, whereas for adolescents it was correlated with consumption frequency of fast food. More recently, Schnettler et al. (2012) reported that higher satisfaction with life is expected if people agree with the statement “my life in

TABLE 8.2 Items^a Included in Personal Well-Being Index ([International Wellbeing Group, 2006](#))**How Satisfied Are You With...**

- ... your life as a whole?
- ... your standard of living?
- ... your health?
- ... what you are achieving in life?
- ... your personal relationships?
- ... how safe you feel?
- ... feeling part of your community?
- ... your future security?
- ... your spirituality or religion?

^aEvaluated on an 11-point scale comprising no satisfaction at all (0) to completely satisfied (10).

TABLE 8.3 Items^a Included in the Satisfaction With Life Scale, Developed by [Diener et al. \(1985\)](#)**Item**

- In most ways my life is close to ideal.
- The conditions of my life are excellent.
- I am satisfied with my life.
- So far I have gotten the important things I want in my life.
- If I could live my life over, I would change almost nothing.

^aEvaluated using a 7-point Likert scale comprising strongly disagree (1) to strongly agree (7).

relation to food and meals is close to ideal.” In addition, [Schnettler et al. \(2015\)](#) reported differences in the eating habits of students with different levels of satisfaction with life. However, it is important to stress that a causal relationship between eating patterns and subjective well-being has not been demonstrated yet.

4.2 Food-Related Well-Being

Specific questionnaires have been developed to measure consumers’ perception of their food-related well-being. These questionnaires can provide useful

insights into the relationship between socioeconomic variables and/or objective indicators of nutritional status and consumer perception of food-related well-being, as well as monitoring the efficacy of public policies aimed at improving diet quality. The satisfaction with food-related life scale is an example of such questionnaire.

The satisfaction with food-related life scale consists of five statements (Grunert, Dean, Raats, Nielsen, & Lumbers, 2007): “My life in relation to food and meals is close to my ideal,” “With regard to food, the conditions of my life are excellent,” “I am generally pleased with my food,” “Food and meals give me satisfaction in daily life,” and “Food and meals are positive elements in my life.” This scale has been validated in different countries and has been reported to have good internal reliability (Cronbach’s $\alpha=0.79-0.88$). Studies have looked at the influence of sociodemographic characteristics and eating habits on satisfaction with food-related life and have shown that people who more frequently eat with their families and eat more meat, milk, fruits, and vegetables are more satisfied with their food-related life (Schnettler, Miranda, et al., 2013; Schnettler, Peña, et al., 2013; Schnettler et al., 2015).

Another more recent methodological approach to measuring food-related well-being is the Well-Being Related to Food Questionnaire (Well-BFQ), developed by Guillemin et al. (2016). These authors used a conceptual framework in which well-being is separated into two main domains, pleasure and health, to develop a questionnaire based on results from 24 focus groups conducted with a total of 198 French consumers. The questionnaire is composed of 134 items, grouped into six modules related to different aspects of consumers’ food behaviors, habits, attitudes, and beliefs: grocery shopping (11 items), dining places (11 items), cooking (15 items), eating and drinking (66 items), commensality (8 items), and eating habits and health (23 items). The items are formatted as statements in the first person to encourage respondents to feel personally involved when describing their own behavior, attitudes, and beliefs, as well as what they think they should do. The response scale for the eating habits and health module ranges from “very unfavorable” to “very favorable,” whereas for the rest of the modules the scales are in a frequency format (“never” to “always”). Principal component analysis performed on responses from 444 French subjects showed that the underlying structure of the questionnaire is composed of 33 dimensions plus 15 single items, which can be aggregated into seven subsections (Table 8.4). In addition, the authors grouped the subsections into four different types of benefits: immediate, direct and short term, deferred health benefits, and well-being. The external validity of the Well-BFQ has been evaluated by correlating well-being measures and diet quality (Allaert et al., 2015). According to the authors, most of the dimensions of the questionnaire received significantly higher scores (corresponding to higher food-related well-being) from participants with balanced diets compared to those with an unbalanced diet.

TABLE 8.4 Factorial Structure of the Well-Being Related to Food Questionnaire (Well-BFQ): Benefits, Subsections, and Dimensions

Benefit	Subsection	Dimension and Number of Items (in Parentheses)
Immediate	Pleasure	Grocery shopping and pleasure (4)
		Cooking and pleasure (4)
		Dining places and pleasure (3)
		Dining places and pleasure in novelty (3)
		Eating alone and pleasure (2)
		Eating and drinking and pleasure (4)
		Eating and drinking and pleasure in discovery (2)
	Security	Grocery shopping and reassurance (3)
		Eating and drinking and reassurance (2)
		Cooking and reassurance (1)
	Relaxation	Cooking and relaxation (6)
		Commensality (3)
		Eating and drinking and relaxation (2)
Direct and short-term benefits	Digestion and satiety	Higher digestive tract discomfort (3)
		Intestinal discomfort (7)
		Early hunger (2)
	Direct consequences (energy and psychology)	Vitality and mood (5)
		Postprandial sleepiness (4)
		Culpability (2)
		Getting to sleep (1)
Deferred health benefits	Eating habits and health	Sleep quality (1)
		Metabolism (6)
		Mood and energy (4)
		Aging (4)
		Bowel movement (3)
		Immunity protection and prevention (3)
		Mobility (3)

Continued

TABLE 8.4 Factorial Structure of the Well-Being Related to Food Questionnaire (Well-BFQ): Benefits, Subsections, and Dimensions—cont'd

Benefit	Subsection	Dimension and Number of Items (in Parentheses)
Well-being	Food behaviors	Grocery shopping and product quality (4)
		Eating and drinking and product quality (4)
		Controlling diet (7)
		Balancing diet (2)
		Adapting diet (3)
		Dining places and atmosphere (5)
		Meal structure (3)
		Tableware (3)
		Greed and snacking (4)
		Cooking and vitamins (1)
		Cooking and utensils (1)
		Cooking and saving time (1)
		Cooking and reassurance—behavior (1)
		Eating alone (1)
		Eating in company (1)
		Commensality—behavior (1)
		Eating and drinking and taking time (1)
		Ready-to-eat dishes (1)
		Eating and drinking and being satiated/ satisfied (1)
		Dietary supplement (1)
		Industrial and enriched products (1)

4.3 Well-Being Associated With Specific Products

Questionnaires that directly evaluate consumer-perceived influence of specific products on well-being/wellness are being incipiently used in the field. Three methodological approaches are presented in the following.

The first attempt to measure consumer-perceived well-being/wellness after food consumption was reported by Boelsma, Brink, Stafleu, and Hendricks (2010). These authors used visual analogue scales to measure consumers' perception of physiological, emotional, and intellectual aspects of wellness after consuming a protein–carbohydrate liquid meal (Table 8.5). Pleasantness scores for some of the feelings (e.g., sleepiness, energetic, alert, full) were also collected, as shown in Table 8.5 for questions with identical numbers but different letters. Participants had to answer each of the questions using 150-mm horizontal line scales ranging from the most negative sensation to the most positive sensation (e.g., very unpleasant to very pleasant). The authors reported that all the items of the questionnaire were related to a single factor (Cronbach's $\alpha=0.74$) and that global measures of wellness increased after consumption of the meal, reaching maximum scores 66 min after consumption. In addition, 240 min after consumption, average wellness scores were significantly higher for high protein/low carbohydrate meals compared to low protein/high carbohydrate meals.

TABLE 8.5 Items^a on the Wellness Questionnaire Used by Boelsma et al. (2010)

Question	Wording
1	How pleasant do you feel at this moment?
2	How satisfied do you feel at this moment?
3	How relaxed do you feel at this moment?
4A	How sleepy do you feel at this moment?
4B	Is this a pleasant or unpleasant feeling to you?
5A	How physically energetic do you feel at this moment?
5B	Is this a pleasant or unpleasant feeling to you?
6A	How mentally alert do you feel at this moment?
6B	Is this a pleasant or unpleasant feeling to you?
7A	How hungry do you feel at this moment?
7B	Is this a pleasant or unpleasant feeling to you?
8A	How full do you feel at this moment?
8B	Is this a pleasant or unpleasant feeling to you?
9	Do you wish to eat something at this moment?
10	How much could you eat at this moment?

Questions identified with letter B refer to the feelings included in questions identified with letter A.

^aEvaluated using 150-mm horizontal line scales.

More recently, [King et al. \(2015\)](#) developed the WellSense Profile questionnaire to measure perceived well-being associated with foods and ingredients. The questionnaire was developed using words (rather than phrases and sentences) extracted from wellness and emotion questionnaires. After a preliminary selection of words by the authors, they used consumer feedback to select words associated with each of five wellness dimensions: physical, emotional, intellectual, social, and spiritual. The final questionnaire comprises a total of 45 items, which are presented in [Table 8.6](#). Respondents are asked to think of when they were eating the focal product and to indicate how much it made them feel in relation to each of the items in the questionnaire using a 5-point scale ranging from not at all (1) to extremely (5). [King et al. \(2015\)](#) evaluated the questionnaire's ability to discriminate between product names (lavender and peppermint) in an Internet survey and among samples in a central location test (meatloaf with differing fat contents and spices and vegetables). Results confirmed the questionnaire's ability to discriminate stimuli in different wellness dimensions.

[Ares et al. \(2016\)](#) developed another questionnaire to measure consumers' perception of well-being associated with specific products based on results from qualitative studies exploring consumer conceptualization of well-being in different countries. The questionnaire was designed to include a global evaluation of well-being, as well as five specific well-being dimensions: physical, intellectual, emotional, social, and spiritual. For each dimension, the most relevant associations elicited by consumers in qualitative studies were selected

TABLE 8.6 Items^a Included in the WellSense Profile Questionnaire ([King et al., 2015](#)) and Dimensions to Which They Are Related

Dimension	Item ^a
Physical	Active, energetic, fatigued, healthy, invigorated, refreshed, resilient, rested, tired
Emotional	Affectionate, calm, happy, loved, relaxed, sad, satisfied, secure, tense
Intellectual	Accomplished, alert, attentive, creative, curious, focused, stimulated, stressed, uninterested
Social	Accepted, approachable, concerned for others, connected, disconnected, friendly, lonely, sociable, supported
Spiritual	Comforted, compassionate, fulfilled, grateful, peaceful, unfulfilled, uninspired, whole

^aEvaluated using a 5-point scale ranging from not at all (1) to extremely (5).

(Ares et al., 2014, 2015) and supplemented with items from other well-being questionnaires. The final questionnaire was composed of 31 statements, which are presented in Table 8.7. In the original application of the scale, respondents were asked to rate their degree of agreement using 7-point Likert scales.

Ares et al. (2016) reported that all the statements of the questionnaire were able to significantly discriminate among nine food concepts (apple, beef, beer, broccoli, chocolate cake, coffee, fish, french fries, and milk) in an Internet survey conducted in seven countries (Brazil, China, France, Portugal, Spain, Uruguay, and the United States). As expected, healthful products received the highest scores on the items of the questionnaire related to physical health, whereas chocolate cake was highly associated with social and emotional aspects of well-being. In addition, the size and the direction of the differences among food concepts depended on the specific well-being dimension being considered. The largest differences among products were found for the item “It is good for well-being,” related to a general evaluation of well-being, as well as for items related to physical aspects of well-being.

Considering that rating each of the 31 statements for each focal sample can be tedious for consumers, Oliveira et al. (2016) replaced scales by a check-all-that-apply question to evaluate consumer-perceived well-being of specific products in a laboratory test. In this approach, consumers are presented with a list of the 31 statements and are asked to select all that apply to describe how the product makes them feel. As an example, Fig. 8.2 shows the frequency of use of the 31 statements for describing orange/pomegranate juices formulated with and without added sugar in a blind evaluation performed by 100 consumers (Oliveira et al., 2016). Several of the statements related to physical aspects of well-being (“It is nutritious,” “It is good for my health,” “It keeps me healthy,” and “It gives me energy”) were frequently used for describing both types of juices, in agreement with the positive healthy image of this product category. In contrast, terms related to intellectual and spiritual aspects of well-being received the lowest frequency of use. Significant differences between the two samples were found for 5 of the 31 well-being statements. The juice sweetened with sugar received a significantly higher frequency of use of the statements “It makes me feel good,” “It is nutritious,” “It gives me energy,” “It gives me pleasure,” “It makes me feel calm and relaxed,” and “It is good for sharing with family” and a significantly lower frequency of use of the statement “It makes me feel sad.” These results suggest that differences in the sensory characteristics of products can influence consumer perception of different aspects of well-being, which could in turn influence their choice.

5. CONCLUSIONS AND REMAINING CHALLENGES

Studying how foods influence consumer-perceived well-being has the potential to contribute to a better understanding of food choices. Studies have shown a

TABLE 8.7 Statements^a Included in the Well-Being Questionnaire Developed by [Ares et al. \(2016\)](#) and Dimensions to Which They Are Related

Dimension	Statement
General	It is good for well-being
	It makes me feel good
Physical	It is good for my health
	It is nutritious
	It makes me feel satiated
	It helps me control my weight
	It keeps me fit
	It keeps me healthy
	It gives me energy
Intellectual	It keeps me alert
	It improves my mental performance
	It improves my memory
	It helps me concentrate
	It makes me think clearly
Emotional	It makes me feel calm and relaxed
	It makes me feel guilty
	It gives me pleasure
	It makes me feel excited
	It makes me feel satisfied
	It makes me feel sad
	It makes me feel happy
Social	It is good for sharing with family
	It makes me feel connected to others
	It improves what others think of me
	It makes me feel supported by others
	It is good for sharing with friends
Spiritual	It makes my life closer to my ideal
	It makes me feel closer to nature
	It gives me a sense of gratitude
	It gives me inner peace
	It is good for my soul

^aEvaluated using 7-point Likert scales ranging from strongly disagree (1) to strongly agree (7).

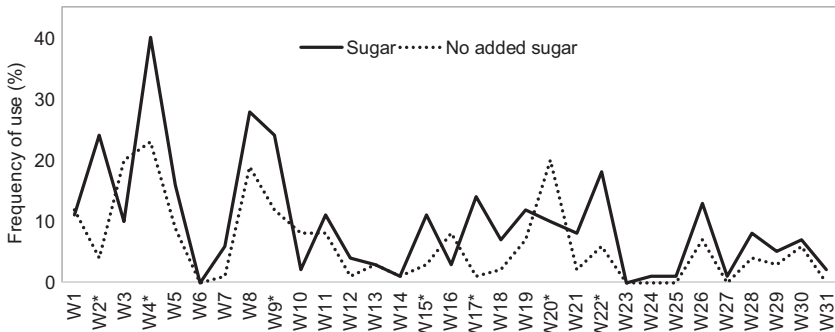


FIGURE 8.2 Frequency of use of the statements of the well-being scale developed by [Ares et al. \(2016\)](#) for describing two samples of orange/pomegranate juice with different added sugar concentrations in a blind evaluation conducted with 100 consumers. Well-being statements: W1, It is good for well-being; W2, It makes me feel good; W3, It is good for my health; W4, It is nutritious; W5, It makes me feel satiated; W6, It helps me control my weight; W7, It keeps me fit; W8, It keeps me healthy; W9, It gives me energy; W10, It keeps me alert; W11, It improves my mental performance; W12, It improves my memory; W13, It helps me concentrate; W14, It makes me think clearly; W15, It makes me feel calm and relaxed; W16, It makes me feel guilty; W17, It gives me pleasure; W18, It makes me feel excited; W19, It makes me feel satisfied; W20, It makes me feel sad; W21, It makes me feel happy; W22, It is good for sharing with family; W23, It makes me feel connected to others; W24, It improves what others think of me; W25, It makes me feel supported by others; W26, It is good for sharing with friends; W27, It makes my life closer to my ideal; W28, It makes me feel closer to nature; W29, It gives me a sense of gratitude; W30, It gives me inner peace; W31, It is good for my soul. Significant differences between samples were found in the frequency of use of the statements highlighted with * ($P < .05$).

relationship between eating patterns and perceived well-being and have demonstrated that consumers perceive differences in how different products influence specific domains of well-being. However, further research is still necessary to confirm whether well-being measurements can provide actionable information for the development of more successful products and public policies aimed at modifying consumers' eating patterns.

From a methodological point of view, several approaches are already being used in the field. These methods differ in the way in which the influence of foods on perceived well-being is measured, and are suited to different types of studies. For example, direct measures of subjective well-being or food-related well-being seem appropriate for correlational studies aimed at investigating the relationship between eating patterns and well-being. In contrast, when the aim of the study is to evaluate consumers' perception of the influence of particular products on different domains of well-being, specific questionnaires seem more appropriate. However, research is still necessary to refine them and to develop best practices. In this sense, the factorial structure of questionnaires measuring perceived well-being of specific products needs to be evaluated across product categories and cultures.

Finally, although research has shown cross-cultural differences in consumer associations with well-being and food-related well-being (Ares et al., 2015), qualitative studies exploring well-being conceptualization in different cultures are still necessary. Previous studies have shown that consumers' conceptualization of the term well-being in a food-related context is strongly related to physical health, which suggests that direct measures of well-being may capture only health-related associations (Ares et al., 2015, 2016). For this reason, it may be recommended not to use the term "well-being" in qualitative studies attempting to capture the holistic nature of this construct. Instead, alternative terms, such as "feeling good" may provide a more holistic measure of the influence of foods on consumers' lives.

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Part III

Psychological and Physiological Measurements

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Chapter 9

Measuring Implicit Associations in Food-Related Consumer Research

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1. INTRODUCTION

Imagine yourself at work. It's 3:00p.m. and you are already feeling exhausted. You decide to grab a coffee and you see an open box of donuts standing next to the coffee machine. The donuts are piled up in the box, they look delicious and fresh. They even release a bit of sweet scent to the area. Before you even realize

it, you have already grabbed that top one and are sinking your teeth into it. It indeed tastes fantastic. While you go back to work half-licking your fingertips, you realize that you have totally forgotten to grab your coffee ... Do you identify with this situation?

This situation is an example of an impulsive behavior that every one of us has experienced in this or a similar way. Why exactly does this happen? The associative and motivational processes that lead to such behavior are of key interest to social scientists. However, a major challenge to assessing such psychological concepts is actually not relying on interfering methods, asking for too personal of insights directly, or simply asking for reasons that are not evident to the individual.

This chapter aims to provide the reader with an overview of theories of the underlying mechanisms causing this behavior, focusing in particular on implicit associations with specific objects, such as food items. We then explain the implicit association test (IAT; [Greenwald, McGhee, & Schwartz, 1998](#)), which is by far the best-known and empirically most widely used procedure (see [Nosek, Hawkins, & Frazier, 2011](#), for an overview on indirect measurement procedures) to capture these “internal” associations. We will describe the reasons for its popularity and widespread applications as well as its caveats in consumer research. Subsequently, newer developments of the IAT will be discussed. We will also describe IAT applications in the food domain and finish this chapter with a case study and possible conclusions to be drawn.

2. THEORETICAL BACKGROUND

Where to start and what to include in a theoretical background on implicit associations and cognitions? One could easily start with Aristotle, who commented extensively on intended behavior and conscious thoughts, or one could include Freud’s psychoanalytic perspective, especially on how he viewed the unconscious. We want to start somewhat more modestly and consider theories of the late 20th and early 21st centuries—20 years of research that influenced almost every social (psychological) question by including automatic/implicit/unconscious processes to explain judgments and behavior (see [Payne & Gawronski, 2010](#), for a historical overview on implicit social cognition).

In the past decades, the general question of *whether* evaluations and attitudes guide behavior has evolved to *how* evaluations and attitudes guide behavior. This movement was inspired by dual-process or dual-system theories (see [Gawronski & Creighton, 2013](#), for a review) in the field of social cognition. The common characteristic of dual-process theories is that they involve two mental processes (e.g., controlled vs. automatic, reflective vs. impulsive, explicit vs. implicit), which guide social behavior and judgments. Gawronski and Creighton differentiate between phenomenon-specific and generalized dual-process theories. Prominent examples of phenomenon-specific dual-process theories include the Elaboration–Likelihood model ([Petty & Cacioppo, 1986](#)), which focuses on

persuasion, or the MODE model (Fazio, 1990), which focuses on evaluations and attitudes and how they influence behavior. Generalized dual-process theories, on the other hand, aim to describe domain-independent mental processes and therefore seek to be integrative and applicable to different phenomena. For associative versus ruled-based processing, the Associative–Propositional Evaluation model (Gawronski & Bodenhausen, 2006) can be named, but also the Cognitive–Experiential Self Theory (Epstein, 1994), as well as Smith and DeCoster’s model (2000). Dual-process theories became influential not only in social psychology but also in other disciplines; especially, Kahneman’s (2003) System 1/System 2 processing model had a big hand in shaping the literature on judgment and decision-making in economics, and even philosophy (e.g., Samuels, 2009). Finally, the most influential dual-process theory as of this writing is the Reflective–Impulsive model (RIM; Strack & Deutsch, 2004).

In the RIM, social behavior is described as a joint outcome of two distinct systems—an impulsive and a reflective system. It differs from other dual-process theories insofar as it assumes that both impulsive and reflective processes can occur consciously and unconsciously. The two systems follow different operating rules and are specified by different principles of representation. They run in parallel and also interact with each other. The impulsive system (IS) enjoys a priority position because it does not require cognitive capacity and is driven by immediate perceptual input. The IS is based on associative networks and elicits behavior through associative links and motivational orientations. In fact, the underlying associative network includes perceptual features, behavioral programs, and valences that form associative clusters, which can become activated and then spread activation to other parts of the specific clusters. It may therefore control behavior less accurately, and less flexibly, but highly effortlessly. In contrast, the reflective system (RS) operates more slowly than the IS, only when an intention and sufficient cognitive capacity are available. To influence behavior, the RS generates a decision (based on stored knowledge) about the desirability and feasibility of a specific behavior; hence, the RS sets a goal and formulates a behavioral intention.

It is assumed that both systems influence behavior through a common pathway that consists of behavioral schemata. Impulsive behavior therefore occurs if the behavioral schemata are activated above a certain threshold through activation spreading in the associative network or by motivational orientations. In contrast, reflective behavior is a consequence of behavioral schemata that were activated intentionally.

Can we use these concepts to explain why you could not withstand the tempting donuts and forgot to grab your coffee? The perceptual input (e.g., the sugar topping, colorful sprinkles, sweet scent) activated the concept “donut” in your associative network, which is a linked structure that combines endless mental representations in your long-term memory. A distributed activation pattern that represents “donut” is associated with a number of other activation patterns, representing, for instance, delicious chocolate, pleasure, sweet, fluffy texture, joy

of eating, coffee, snack break, but also guilt, calories, and perhaps even avoidance. But because you felt exhausted, your RS did not have enough cognitive capacity to generate a behavioral intention (e.g., I will not eat a donut) that would have been coherent with your dieting goals and that would have activated a different behavioral schema. Instead, only the positive part of the associative cluster was activated, which in turn elicited an associated approach orientation, and your behavioral schema triggered the execution of your behavior; hence, you approached the box, picked up a donut, put it in your mouth, and ate it.

Now imagine that a scientist would like to ascertain your attitude toward donuts to predict future snacking behavior. A behavioral scientist would most likely ask you to give consent for him or her to quietly observe the scene. A traditional social psychologist (or consumer researcher) would by default try to measure your attitude directly, asking you to rate the degree to which you like or dislike donuts on, for instance, a visual analogue scale or a Likert scale. A social cognition researcher, on the other hand, would see this as problematic: direct measurement approaches require that people have sufficient introspective abilities to generate an accurate response to a direct measure. Consumers need to be willing to report their responses in an unbiased manner and the answers provided could depend on the context and, for instance, vary by who asks the questions, how the questions are asked, and where the questions are asked (Sudman, Bradburn, & Schwarz, 1996). Most importantly, direct measurements may change the nature of an evaluative process from impulsive/implicit to reflective/explicit.

Finally, to address some of these concerns, a social scientist with a background in implicit social cognition would test you with an indirect measurement procedure, and try to assess your IS by indirectly measuring your implicit associations with such donuts.

Before we make you an expert in indirect measurement procedures, we will provide definitions of the terminology commonly used in the area of social cognition, which will be used throughout the chapter.

3. DEFINITIONS

Four of the most commonly heard terms when discussing methodological issues around dual processes are implicit and indirect, on the one hand, and explicit and direct, on the other. Although these pairs of terms are often used interchangeably, there are important differences between them. In this chapter, we will follow the terminology of De Houwer et al. (De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009), where implicit (as well as explicit) refers to features of a psychological construct (e.g., an attitude) and consequently translates to the measurement outcome (e.g., a score). In contrast, the term indirect (as well as direct) describes the characteristics of the specific measurement procedure and therefore refers to the measurement itself (e.g., an indirect or direct assessment). Importantly, a measure can be defined as implicit if the measurement procedure

causally produces the measurement outcome through the psychological attribute in an automatic manner.

Today, a variety of indirect measurement procedures exist. Nosek et al. (2011) listed 20 different indirect procedures that received attention in the *Handbook of Implicit Social Cognition* (Gawronski & Payne, 2010) and that have been applied at least once outside of their original publication. In their review, most of the research evidence involves the IAT, followed by the sequential Evaluative Priming Task (Fazio, Sanbonmatsu, Powell, & Kardes, 1986) and the Semantic Priming Task (Wittenbrink, Judd, & Park, 1997). However, as mentioned earlier, in this chapter we will focus on the IAT and its procedural modifications.

4. IMPLICIT ASSOCIATION TEST

4.1 History

An incredible number of researchers have applied the IAT to assess implicit constructs, shed light on the underlying processes, or investigate possible methodological issues (i.e., the original publication has been cited approximately 8000 times). Initially, the IAT was developed in the field of social psychology (for introductory chapters, see Gawronski, Deutsch, & Banse, 2011; Teige-Mocigemba, Klauer, & Sherman, 2010) and since then has stimulated a great deal of research in many different disciplines of psychology as well as applied sciences (for a metaanalysis, see Greenwald, Poehlman, Uhlmann, & Banaji, 2009).

The IAT belongs to the family of response interference tasks, hence, it is based on a response interference whereby an apparently irrelevant stimulus elicits an automatic response that may either facilitate or inhibit fast and correct responses in the primary task. It was developed to tap into unconscious associations that are inaccessible to introspection and that are overlaid by newer associations, which supposedly lead to observable changes in direct self-reports (e.g., Greenwald & Banaji, 1995). However, more recently it has been suggested that indirect procedures, such as the IAT, rather reflect mental associations that might be only temporarily accessible and that may have a chronic and/or situational source, in other words, mental associations that are constructed on the spot and that might be highly influenced by the context (e.g., Gawronski & Bodenhausen, 2006; Strack & Deutsch, 2004).

4.2 Methodology and Possible Issues to Consider

4.2.1 Task Structure

The IAT is a computer-based indirect measurement procedure that involves two binary categorization tasks. Each task is based on one attribute dimension (e.g., positive vs. negative) and one target dimension (e.g., chocolate vs. fruit) and

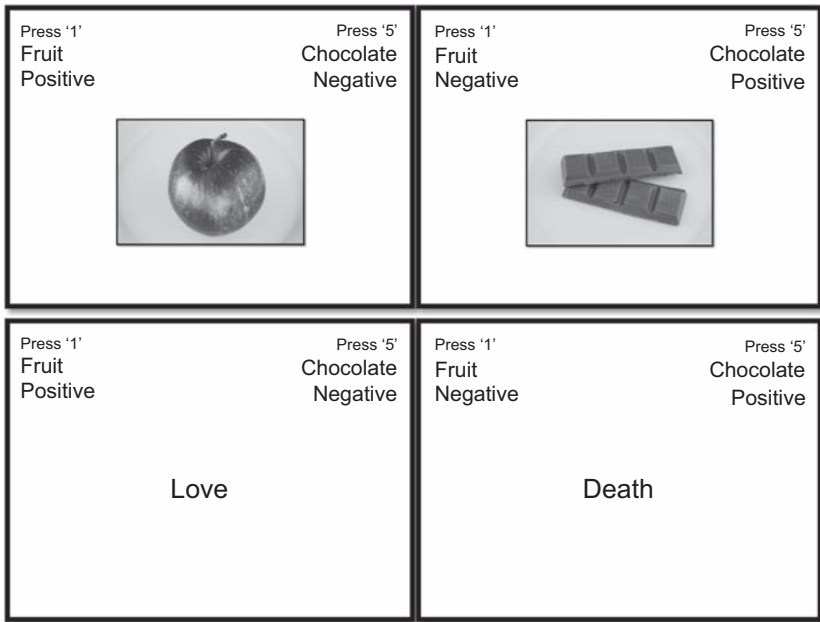


FIGURE 9.1 Four different screenshots of a computer that runs an implicit association test (IAT). The IAT follows a fixed block structure, hence, each categorization task remains constant on the screen and changes block-wise (see left vs. right column). In this example, three of the four presented stimuli would require pressing the response key “1”, whereas the chocolate stimulus requires a response with “5”.

combined in either an association-congruent or an association-incongruent way. Typically, the four labels of the two target dimensions are present throughout the task in the upper part of the screen, next to an indication of the two keys that shall be used for categorization of the stimuli. Each dimension is represented through words or images that appear, one after another, at the center of the screen. Each stimulus is then categorized by using one of the two assigned response keys. In one of the two categorization tasks, concepts are combined in such a way that participants have to respond to fruit images and positive words with the left key (i.e., key “1”) and to chocolate images and negative words with the right key (i.e., key “5”; see Fig. 9.1, left column), whereas the other task combines the four concepts in the opposite manner (see Fig. 9.1, right column). Participants have to categorize the stimuli according to the two dimensions as fast and accurately as possible, while their individual performance (e.g., response latencies, error rates) is measured.

An IAT is based on the idea that automatic associations underlie those concepts and thus facilitate or inhibit task responses. It is assumed that if a categorization task is combined in an association-compatible manner, responses should be faster and/or errors should be fewer compared to the

TABLE 9.1 Task Structure of a Standard Implicit Association Test Designed to Assess Evaluative Associations of Fruit Relative to Chocolate

Block		Trial Number	Left Key	Right Key
1	Practice	20	Fruit	Chocolate
2	Practice	20	Positive	Negative
3	Practice	20	Fruit	Chocolate
			Positive	Negative
	Test	40	Fruit	Chocolate
			Positive	Negative
4	Practice	20	Negative	Positive
5	Practice	20	Fruit	Chocolate
			Negative	Positive
	Test	40	Fruit	Chocolate
			Negative	Positive

opposite, association-incompatible categorization task. The standardized difference between the mean reaction times of the two categorization tasks (the “IAT effect”; see [Section 4.2.3](#), Scoring Procedures) is taken as an index of automatic preferences and attitudes ([Greenwald et al., 1998](#); [Greenwald, Nosek, & Banaji, 2003](#)).

The task structure of a typical IAT includes five different blocks that are divided into practice and test trials (see [Table 9.1](#)). The IAT follows a fixed block structure whereby categorization tasks change between blocks, although concepts and their assigned response keys are usually counterbalanced across participants.

Generally, the IAT is a very flexible tool that combines pairs of attribute concepts relatively freely with pairs of target concepts. For example, evaluative attribute dimensions (e.g., positive vs. negative) can be used to assess relative preferences between target categories (e.g., products, people, objects, concepts). Furthermore, nonevaluative dimensions (e.g., extraverted vs. introverted) can be used to assess semantic associations, and behavioral dimensions (e.g., approach vs. avoidance) can be used to assess motivational tendencies (for applications in the food domain see [Section 5](#)).

4.2.2 Psychometric Qualities

One of the reasons for the great popularity of the IAT is probably its very high and satisfying internal consistency estimates and generally large effect sizes. In

a metaanalysis, Hofmann, Gawronski, Gschwendner, Le, and Schmitt (2005) reported an overall estimated reliability coefficient (internal consistency and split-half) of 0.79, but a mean test–retest reliability of only 0.51. This discrepancy is puzzling and gives suspicion to concluding stable underlying attitudes. This indeed is in line with studies in which the IAT has been found sensitive to context effects (see Gawronski & Bodenhausen, 2006, for an overview) or strategic effects, such as faking (e.g., Fiedler & Bluemke, 2005; Steffens, 2004).

Most of the IAT validation research has been conducted at the individual level with correlative data and much less at the group level with, for instance, the known-group approach (e.g., Banse, Seise, & Zerbes, 2001; Tibboel et al., 2011) or with a full experimental approach (e.g., Olson & Fazio, 2001). By following the correlative approach, IAT data can be validated with other indirect, self-reported, or behavioral measures. Two metaanalyses reported an overall estimated correlation of $\rho=0.24$ (based on 126 independent samples; Hofmann et al., 2005) and $\rho=0.21$ (based on 155 independent samples; Greenwald et al., 2009) between direct measures and IAT results. However, the estimated standard deviation of 0.14 (or $SD\rho=0.26$, respectively) implies a rather high variation between the reported, single-study correlations. In fact, early IAT studies often found no correspondence between direct and indirect measures (e.g., Karpinski & Hilton, 2001). However, as the field grew, more and more studies have shown higher correspondence under certain conditions; consequently, the research focus shifted and relevant moderators were identified. Hofmann et al. (2005) concluded that responses from indirect and direct methods are more strongly related if (1) the two tasks are reliable (e.g., have a small measurement error), (2) the two tasks involve similar stimuli and responses, and (3) self-reported responses are quick, intuitive reactions instead of deliberated answers.

Unfortunately, the predictive validity of the IAT has not been as high as initially hoped. Greenwald et al. (2009) reported an average correlation of $\rho=0.27$ ($SD\rho=0.22$, based on 184 independent samples) between the IATs and behavioral criteria. Again, based on the estimated standard deviation, this overall correlation seems rather low and unstable across studies. However, compared with the average correlation between direct measures of attitude and similar behavioral criteria ($\rho=0.36$, $SD\rho=0.39$, based on 156 independent samples), the correlation is more satisfactory. Analyzing only consumer behavior–relevant studies, a lower mean implicit-behavior criterion correlation ($\rho=0.32$; $SD\rho=0.17$; based on 40 independent samples) was reported compared to the mean explicit-behavior criterion correlation ($\rho=0.55$; $SD\rho=0.26$; based on 38 independent samples).

Nevertheless, all correlation coefficients show large variations in their effects, which is why Friese, Hofmann, and Schmitt (2008) directed more attention to the boundary conditions under which various indirect measurement procedures are more or less likely to predict behavior. Derived from dual-process theories, they developed a classification system of moderators that influence

automatic versus controlled information processing. Based on their review, it can be concluded that indirect measurement procedures primarily predict behavior if an individual has low opportunity or low motivation to control his or her information processing and consequently his or her behavior. Identified dispositional moderators are, for instance, working memory capacity (e.g., Hofmann, Gschwendner, Friese, Wiers, & Schmitt, 2008) or self-control (e.g., Friese & Hofmann, 2009), whereas situational moderators include temporally reduced cognitive capacity (e.g., Friese, Hofmann, & Wänke, 2008) or processing time (e.g., Friese, Wänke, & Plessner, 2006) or the influence of alcohol (Hofmann & Friese, 2008). Finally, indirect measurement procedures have an increased predictive validity when individuals generally have a preference for intuition or when they situationally rely on automatic processes to guide their behavior (e.g., affective vs. cognitive focus; mood; regulatory focus).

Taken together, the psychometric qualities of the IAT do not seem too convincing per se; however, when considering possible moderating effects, the IAT (and its variation) is well suited to predicting behavior.

4.2.3 Scoring Procedures

Several methods to calculate the relative difference between the two categorization tasks (the IAT effect) have been developed. Originally, a scoring procedure was suggested that required latencies to lie within boundaries of 300–3000 ms, dropping the first two trials of each block and log-transforming the final data. Greenwald et al.'s (1998) main justification of this was based on larger final effect sizes. Later, Greenwald et al. (2003) reported a revised scoring algorithm, whereby they studied five different measures of central tendency and so based the relative difference between the two IAT categorization tasks either on the mean, median, log-transformed, reciprocal response latencies or on D . In fact, D is closely related to Cohen's effect size measure d (Cohen, 1977) and standardizes response latencies for individual variability (e.g., general processing speed, attention span, hand–eye coordination) by dividing the mean difference of the two categorization tasks with the individual pooled standard deviation of all latencies. Indeed, D outperformed the former measures; however, this evaluation was based on only two rather questionable criteria (i.e., correlating high with direct measures and low with the overall average latency) that seem controversial to the basic idea of developing implicit measures (for a discussion, see Rothermund, Wentura, & De Houwer, 2005; Wentura & Rothermund, 2007). In their paper, Greenwald et al. continued their evaluation with various validity and reliability aspects, tested different scoring procedures (e.g., error treatment, included test and practice trials, cut-off values for recoding outliers) on D -transformed or log-transformed latencies, and finally suggested an improved scoring algorithm, the so called D score. Based on metaanalytic results, the D score is the most commonly used scoring algorithm today (i.e., used in 70 of 145 IAT studies); interestingly, no significant effect of the D score compared to other scoring procedures was discovered.

Because the IAT, and consequently the calculated IAT effect, is based on a comparison of two opposing tasks, resulting scores can never be interpreted as absolute and instead reflect relative preferences (e.g., a preference for chocolate over fruit, see the example in Fig. 9.1). A debate that addressed the relative nature of the IAT and other scoring-related issues was fruitful in terms of psychometrical improvement and general understanding of the IAT (Blanton, 2007; Blanton & Jaccard, 2006; Blanton, Jaccard, Gonzales, & Christie, 2006; Nosek & Sriram, 2007).

4.2.4 *Alternative Explanations of the IAT Effect*

Following Greenwald and colleagues' interpretation, the IAT effect is assumed to be caused by strong associations between the category pairs of the two categorization tasks (see Greenwald et al., 1998), which is in line with the common understanding of attitudes (Fazio, Chen, McDonel, & Sherman, 1982; Fazio et al., 1986). Even though this interpretation seems intuitively valid, an alternative account that is known as recoding describes the work of several researchers and stands for strategic simplification of one of the two categorization tasks (e.g., De Houwer, 2003; Gast & Rothermund, 2010; Mierke & Klauer, 2003; Rothermund, Teige-Mocigemba, Gast, & Wentura, 2009; Rothermund & Wentura, 2004). Specifically, it has been argued that participants might simplify one of the two categorization tasks by ignoring the category membership of the stimuli, relying instead on other features that help distinguish them and thereby reducing the complexity of the discrimination from one involving four sets of concepts to a one involving only two sets.

In principle, every shared feature can be used for recoding strategies, for instance, perceptual qualities of the stimuli like salience, size, color, familiarity, environmental or extrapersonal knowledge, or simply the valence of the material used (for a review of these confounding factors, further contaminating effects, and possible remedies, see Teige-Mocigemba et al., 2010). If these features that have been used for recoding are known, it is often possible to statistically isolate their effect and separate them from the variation in the construct that the test is actually supposed to measure. Mathematical models that try to take possible confounding factors into account include the Quad model (Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005), the Random-Walk model (Brendl, Markman, & Messner, 2001) or the Real model (Meissner & Rothermund, 2013). In contrast, if the features are unknown or if participants engage in highly idiosyncratic recoding strategies, it is difficult to control their effects by statistical methods. To detect if an IAT effect was contaminated by recoding processes, control IATs (e.g., task-switching ability IAT by Back, Schmuckle, & Egloff, 2005, or Mierke & Klauer, 2003, for a geometry IAT) can be correlated with the contextual IAT (e.g., Teige-Mocigemba, Klauer, & Rothermund, 2008), or different experimental conditions can be compared to detangle the underlying processes (e.g., Kinoshita & Peek-O'Leary, 2006; Rothermund & Wentura, 2004).

Finally, a seemingly obvious way to reduce recoding processes is to construct the stimuli in such a way that the features supposed to distinguish them are not confounded with other features not supposed to distinguish them (De Houwer, 2001) or by eliminating the fixed block structure of an IAT that has been argued to support recoding strategies. The latter approach was followed by the authors of two procedural variations of the IAT, the single-block IAT (SB-IAT; Teige-Mocigemba et al., 2008) and the recoding-free IAT (IAT-RF; Rothermund et al., 2009), which will be described in the following section.

4.3 Further Developments of the Implicit Association Test

Despite the popularity of the IAT (or perhaps because of it), various criticisms concerning deficiencies have been raised, which have led to several remedies and procedural variations of the IAT over the years. For instance, the single-category IAT (SC-IAT; Karpinski & Steinman, 2006), the single-target IAT (Wigboldus, Holland, & van Knippenberg, 2004), and the single-attribute IAT (Penke, Eichstaedt, & Asendorpf, 2006) have been developed to address the relative nature of an IAT (for an overview of limitations, see Gawronski et al., 2011). The personalized IAT (Olson & Fazio, 2004) takes the possibility of extrapersonal associations into account, whereas the brief IAT (Sriram & Greenwald, 2009) uses a limited number of trials and a less complex structure to suit research, for instance, with children (however, for a critical debate, see Friesen & Fiedler, 2010; Greenwald & Sriram, 2010; Rothermund & Wentura, 2010). Two IAT variants that tackle the central problem of recoding will be described in detail in the following sections.

4.3.1 The Single-Block IAT

The SB-IAT (Teige-Mocigemba et al., 2008) is a procedural variation that eliminates the fixed block structure of the standard IAT and thereby successfully reduces recoding processes. While the two categorization tasks vary between blocks in the standard IAT (see Table 9.1), they are kept constant in the SB-IAT and vary randomly across trials. In fact, one categorization task is defined in the upper and the other in the lower part of the computer screen. The position of the stimulus indicates the categorization task and the relevant key assignment.

In the example illustrated in Fig. 9.2, a participant would need to press the left key if an image of a fruit or a positive word appeared in the upper part of the screen and also if a chocolate image and a positive word were shown in the lower part of the screen. For the right key it would be the opposite assignment: a picture showing chocolate or a negative word in the upper part of the screen and a fruit image or a negative word in the lower part of the screen.

In the original publication, Teige-Mocigemba et al. (2008) provided evidence for reduced recoding strategies and reduced systematic method-specific variance in the SB-IAT. Effects from an SB-IAT were generally smaller compared to a standard IAT, which was caused by the reduced method-specific variance in the

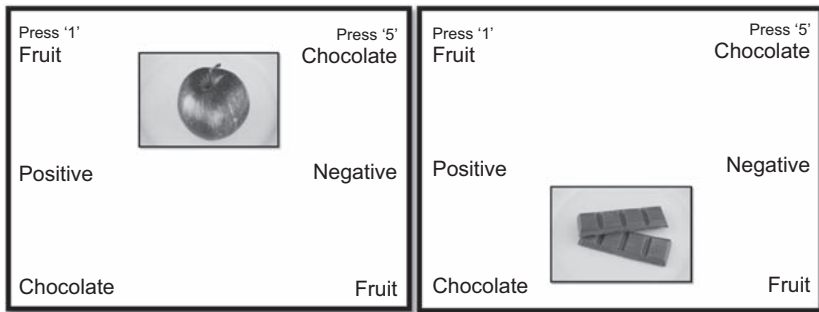


FIGURE 9.2 Two screenshots of a computer that runs a single-block implicit association test (SB-IAT). In the SB-IAT, the two categorization tasks remain constant on the screen and change randomly from trial to trial between the upper and the lower part of the screen. The position of the stimulus indicates the assigned response key; hence, “1” would be required in both examples.

SB-IAT. On the one hand, the SB-IAT was found reliable (Cronbach’s α ranging between 0.60 and 0.90), was able to discriminate between individuals, and correlated with direct measures to the same extent as a standard IAT. On the other hand, the SB-IAT’s somewhat complicated structure remains a serious concern. The authors conducted both experiments with a student population and reported no difficulties or differences in terms of error rates and mean latencies compared to the standard IAT. However, it is theoretically possible that participants could develop other task-switching strategies. The authors argued that any effect resulting from such strategies should affect both categorization tasks equally. If present at all, such effects would merely lead to an increase in unsystematic error variance, reducing the reliability of the test but not resulting in systematic bias.

4.3.2 The Recoding-Free IAT

The IAT-RF (Rothermund et al., 2009) is very similar to the standard IAT (see Fig. 9.1); however, the two categorization tasks change at random from trial to trial and do not remain constant on the screen as in the standard IAT or the SB-IAT. At the beginning of each trial, the four category labels are presented in the right and left corners to indicate the specific categorization design and the assigned response keys for the subsequent trial. In the fruit–chocolate example, the response assignments for the target category (e.g., fruit on the left side and chocolate on the right side) would remain constant throughout the entire IAT-RF; the labels for the attribute category (e.g., positive and negative on either the left or the right side) would switch randomly between the trials. The randomly occurring switches of the categorization tasks between trials force participants to categorize all presented stimuli by their task-relevant category membership and therefore show smaller compatibility effects and have equal task-switch cost in both test tasks (Experiment 1). Nevertheless, the IAT-RF could create a different kind of task-switching cost but, as the authors note, these mapping costs do not indicate any simplification for one of the two test

tasks and therefore are unrelated to recoding processes (Experiment 2). As for the SB-IAT, general effects have been found to be smaller in size owing to reduced method-specific variance.

Altogether, the SB-IAT and the IAT-RF appear to be very promising paradigms that assess implicit processes more clearly and with less bias than the standard IAT. However, more research is needed to evaluate both paradigms in more detail—especially research applying the SB-IAT is rare. For the IAT-RF, [Houben, Rothermund, and Wiers \(2009\)](#) have investigated its ability to predict (self-reported) behavior. [Kraus and Scholderer \(2015\)](#), as well as [Kraus and Piqueras-Fiszman \(2016\)](#), successfully compared and applied a motivational variant of the IAT-RF and assessed motivational tendencies (in contrast to evaluative associations) toward foods (see [Section 5.2](#)).

5. APPLICATIONS IN THE FOOD DOMAIN

A vast number of researchers from different disciplines, including the sensory perception, and nutritional behavior domains, have been interested in applying indirect measurement procedures to uncover the mechanisms of people's perception of, and attitudes and motivations toward, food. This section will provide an overview of the research developed using IAT (and variations hereof) in the food and nutrition domain from 2007 to 2016. The overview is based on 43 consumer-based empirical studies that were found by using “food” and “implicit association” as keywords in the Scopus database in September 2016.

5.1 Evaluative Associations Toward Food Categories

5.1.1 Standard IAT (With Two Targets)

Most of the literature using IATs has focused on the link between two specific food categories (e.g., high calorie vs. low calorie) or two different categories (foods vs. sports or other objects) and pleasant/positive and unpleasant/negative evaluative concepts. In addition, some researchers have used the IAT to investigate people's association between high- or low-calorie foods and tastiness (or lack thereof) (e.g., [Mai & Hoffmann, 2015](#); [Mai, Hoffmann, Hoppert, Schwarz, & Rohm, 2015](#)). Studies looking into “preference” (as a relative measure of valence-related evaluation) include, for instance, comparisons of Western versus Japanese breakfast ([Kimura et al., 2010](#)), fruit consumption habits ([De Bruijn, Keer, Conner, & Rhodes, 2012](#); although they used utensils as the other target category), meat versus vegetables ([De Houwer & De Bruycker, 2007b](#)), tasty versus not tasty foods ([De Houwer & De Bruycker, 2007a](#)), low-fat/calorie versus high-fat/calorie food (e.g., [Ackermann & Palmer, 2014](#); [Ayres, Conner, Prestwich, & Smith, 2012](#); [Conner, Perugini, O’Gorman, Ayres, & Prestwich, 2007](#); [Maas, Keijsers, Rinck, Tanis, & Becker, 2015](#); [Mattavelli et al., 2015](#)), sweet versus not sweet food ([Sartor et al., 2011](#)), and food versus sports ([Seibt, Häfner, & Deutsch, 2007](#)), among relevant segments of the population. In this section we will discuss in more detail a series of such types of studies.

Craeynest, Crombez, Haerens, and De Bourdeaudhuij (2007) used two personalized IATs to investigate whether overweight youngsters implicitly prefer their own chosen palatable food over a hobby (that was equally attractive for them), and separately, whether they implicitly prefer unhealthy food over (for the participants) equally palatable healthy food, compared to a matched group of lean controls. In both IATs the attribute categories were positive and negative words. It should be noted that the authors aimed for equal “attractiveness” and palatability in the different target categories shown to manipulate only their parameter of interest (i.e., healthiness perception). The results turned out to reveal that none of the groups differed, both having equal preference between food and hobbies and that they both preferred healthy food. Craeynest, Crombez, Koster, Haerens, and De Bourdeaudhuij (2008) then investigated why both groups implicitly preferred the healthier foods. For this purpose, they looked into the possible association between high-fat food and levels of arousal by using food images this time. In the first of two experiments, overweight and lean youngsters completed two arousal-based IATs. In a positive version of this IAT, implicit associations between fat versus lean food and high- and low-arousal (positive) words were assessed. In a negative version of this IAT, high- and low-arousal (negative) words were used instead. The authors replicated this experiment comparing lean and severely obese youngsters in their second experiment. The results of these two experiments revealed strong implicit associations between high-fat food and high-arousal words (compared to lean food and low-arousal words) in the three groups. However, no differences were found between the positive and the negative arousal-based IATs, that is, there was no difference in terms of the arousal’s valence. So can one conclude that high-fat food evokes higher levels of arousal in general? Not quite. As discussed above, the IAT provides only a measure of relative association between nominal categories, since two target concepts and two attribute concepts are needed. This means that, in fact, it is impossible to determine whether the results were driven by associations between high-fat food and high arousal or by associations between lean food and low arousal. One remedy here would be to use an SC-IAT (Karpinski & Steinman, 2006, discussed later in Section 5.1.2).

Finally, these IAT effects may have also been a result of the aforementioned recoding strategies and specifically due to a higher saliency of two of the four categories (Rothermund & Wentura, 2004). It is possible that the combination of high-fat food and high arousal was simply more salient (e.g., because both are often presented together in advertisements of high-fat food) rather than the conceptual association indicating that high-fat food evokes arousal.

5.1.2 Single-Category IAT (With One Target)

From the example in the previous section it seems that to measure the strength of an association toward a specific target, two target categories are not always necessary, and in fact using two could bring difficulties in interpreting the

results. But do relative variants of the IAT (like the standard IATs, with two target categories) reveal the same information as nonrelative variants such as the SC-IAT (Karpinski & Steinman, 2006), which uses only one target category? We address this question with the following example.

Houben, Roefs, and Jansen (2010) conducted two studies to investigate whether dietary restraint is associated with stronger positive implicit attitudes toward high-calorie food. This hypothesis was tested in the first experiment using two standard IATs with unipolar attribute categories to separately measure positive (vs. neutral) and negative (vs. neutral) implicit associations with high-calorie food versus low-calorie food in their target dimension. Let us focus on the results of only the positive (vs. neutral) IAT because in the negative (vs. neutral) IAT no differences were observed. When positive implicit associations with high-calorie food were measured relative to low-calorie food, restrained and unrestrained eaters did not differ with respect to their implicit preferences for high- versus low-calorie food. In the second experiment, when positive (vs. neutral) implicit associations with only high-calorie food were assessed using the SC-IAT, restrained eaters showed stronger positive implicit associations with high-calorie food than unrestrained eaters (see also Houben, Roefs, & Jansen, 2012). These findings suggest that the relationship between dietary restraint and implicit preferences for high-calorie food may be better examined using nonrelative measures like the SC-IAT. The authors argued that any strong relationship between dietary restraint and implicit preferences could become blurred when using relative measures like the standard IAT, which involve a contrast between two target categories. In the case of the first experiment, it could be possible that the two IATs not only measured implicit associations with high-calorie food, but also were affected by implicit associations with low-calorie food. That said, the opposite could also be put forward, namely that relative methods could lead to enhanced effects toward one of the categories precisely because of a contrast effect (see also Bongers, Jansen, Houben, & Roefs, 2013, for a case of the use of specifically positive and negative emotion terms as attribute categories; and see Lebens et al., 2011, for a similar approach on snack foods).

Several other authors have used the SC-IAT because there was only one target category of interest. For example, Stafford and Scheffler (2008) applied an SC-IAT and found that participants who had not eaten lunch were significantly faster in categorizing general food words sharing the same response key with pleasant words compared to when food words shared the unpleasant response key, compared to a group that had eaten lunch. Stafford, Wright, and Yeomans (2010) also used this approach to reveal differences in attitude toward caffeine between different types of caffeine consumers. Further studies applying this approach include the study of high-fat foods (Türk Pereira, 2010; Yamanaka, Yama, & Yogo, 2012) and chocolate (Wang et al., 2015). Haynes, Kemp, and Moffitt (2015, 2016) also incorporated a recoding-free structure into their SC-IAT to measure the implicit attitudes

of individuals toward high-calorie foods. Finally, [Thomas, Judge, Brownell, and Vartanian \(2006\)](#) applied an SC-IAT and had participants associate anorexia with either glamour or danger.

5.2 Motivational Associations Toward Food Categories and Self/Social Representations

Researchers have also developed motivational IATs, in which, instead of an evaluative dimension (e.g., positive vs. negative; good vs. bad), they incorporated a motivational dimension (e.g., I want vs. I don't want; approach vs. avoid). Although the majority of studies applying such versions focused on addictive substances like tobacco or alcohol as their target concepts (e.g., [Farris, Ostafin, & Palfai, 2010](#); [Ostafin, Marlatt, & Greenwald, 2008](#); [Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011](#); [Wiers, Rinck, Kordts, Houben, & Strack, 2010](#)), some researchers have investigated the effects of hunger, obesity or weight-related diseases in individuals' motivational tendency toward foods. For instance, [Ashby and Stritzke \(2013\)](#) used a standard IAT procedure and applied a motivational dimension to measure people's implicit motivations toward high- and low-calorie foods. [Kemps, Tiggemann, Martin, and Elliott \(2013\)](#) reported two experiments designed to establish and modify such associations specifically in the food craving domain. Experiment 1 used an IAT-RF to examine approach–avoidance associations with pictures of chocolate versus pictures of food items not containing chocolate in a sample of 48 undergraduate women. Participants were faster to respond to trials that paired chocolate pictures and approach words (and nonchocolate food items and avoid words) than to the opposite pairings. The magnitude of this approach bias was positively correlated with participants' reported chocolate craving. Experiment 2 examined whether chocolate-related approach associations can be modified. Using a modified IAT-RF, 96 undergraduate women were trained to associate chocolate pictures either with approach or with avoid words. To achieve this, 90% of the trials involved a particular pairing. As predicted, chocolate–approach associations increased in the approach group and decreased in the group that was trained with chocolate–avoidance pairings. Additionally, the approach group reported stronger chocolate cravings after training; in contrast, cravings tended to decrease in the avoid group. These results are consistent with incentive- and cognitive-motivational accounts of craving, and support and extend reports of approach biases (and the retraining of those biases) for other substances, including alcohol and cigarettes, to the food domain. They also offer potential scope for curbing unwanted food cravings in the context of problem eating behavior.

The IAT-RF has also been shown to be sensitive enough to assess different motivational approach–avoidance tendencies toward two types of food depending on the experimentally manipulated state of hunger of the participants ([Kraus & Piqueras-Fiszman, 2016](#); see [Section 6](#) for a detailed description of

this study). Interestingly, an evaluative variant did not differentiate between the two groups, which can be interpreted as the assessment of a general “liking,” while the motivational variant was able to capture the “wanting” component of food reward (for a methodological debate, see [Finlayson & Dalton, 2012](#); [Havermans, 2012](#); [Havermans, Giesen, Houben, & Jansen, 2011](#)).

In 2017, [Koranyi, Grigutsch, Algermissen, and Rothermund \(2017\)](#) highlighted the importance of a true motivational component being included in a measure of implicit wanting. For this purpose, they ensured that participants were in a specific need state during a “true wanting” IAT with a motivational attribute dimension (I want vs. I don’t want), a “pseudo-wanting” IAT (I want vs. I don’t want), or a standard “liking” IAT with an evaluative dimension (positive vs. negative). The need state was thirst and the stimuli in the true wanting IAT were drinks versus neutral objects. In the pseudo-wanting tasks participants were still thirsty but the images also included other desirable items (e.g., a smartphone) that were not related to their need state (thirst). The novelty further relied on the fact that participants could get water (their incentive) whenever a drink-related image was displayed and participants had to categorize it with “I want” instead of “I don’t want.”

Finally, IATs have also been applied to measure people’s self-esteem in weight-related issues or attitudes toward stereotypes related to food and physical appearance (e.g., [Carels et al., 2013](#); [Heim-Dreger, Eschenbeck, & Kohlmann, 2013](#)).

5.3 Implicit Associations Between Sensory Modalities

Researchers have used the IAT to measure the strength of associations between sensory modalities. For instance, [Crisinel and Spence \(2009\)](#) investigated the interactions between auditory stimuli and basic tastes. Participants completed a version of the IAT to measure the strength of the association between high- (vs. low-) pitched sounds and the names of food with a sour (vs. bitter) taste. In a separate study [Crisinel and Spence \(2010\)](#) further demonstrated the existence of robust correspondence between sound pitch and basic taste by including sweet (vs. sour) taste in an IAT and go/no-go task. Analysis of the sensitivity of participants’ responses suggested that both sour- and sweet-tasting (names of) food items were associated with high-pitched sounds, while bitter foods were more strongly associated with low-pitched sounds. Results from these studies highlight the existence of robust cross-modal associations between certain sounds and basic tastes, which had been typically overlooked when considering the multisensory perception of food.

An IAT was also implemented to determine associations between packaging elements and the characteristics of the content. For instance, [Piqueras-Fiszman and Spence \(2011\)](#) used a variation of the IAT to investigate the color–flavor correspondences in product packaging, showing that frequent consumers of a

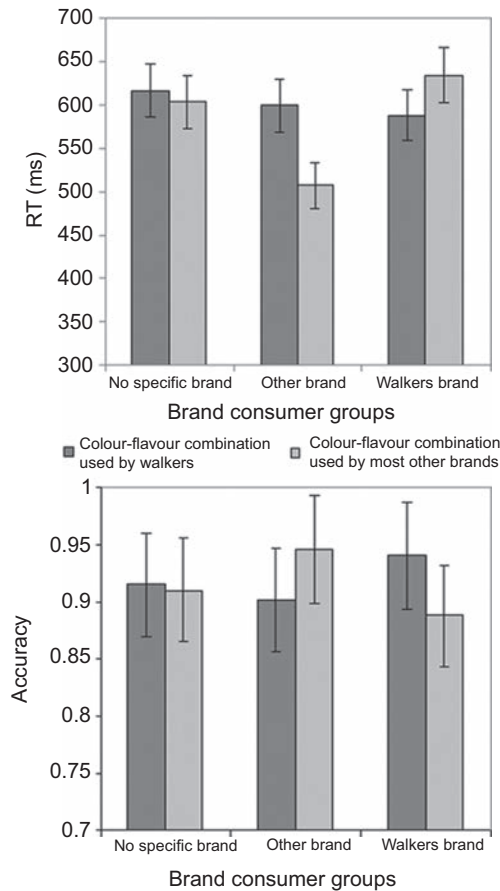


FIGURE 9.3 Representation of reaction times (*RT*, top) and accuracy (in proportion from 0 to 1; bottom) of three different brand clusters who consumed Walkers crisps, a brand different from Walkers, or no specific brand. Consumers of Walkers in the United Kingdom were faster and more accurate with blocks of the combination that the brand uses. The opposite was observed with the consumers of other brands, which use the opposite color–flavor pairing.

certain brand had stronger association between the color–flavor combination used by that brand than that of the competitors, while consumers of no particular brand exhibited equal association between any of the options (Fig. 9.3).

6. CASE STUDY ON THE IAT-RF

In a 2015 research article [Kraus and Scholderer \(2015\)](#) investigated two procedures to indirectly measure motivational approach–avoidance tendencies and assessed their convergent, discriminant and predictive validity by comparing them to self-reported measures and actual behavior. The two procedures were

based on the standard IAT and the IAT-RF. As we have learned in the previous sections, typically IATs are implemented to indirectly assess evaluative associations. However, Kraus and Scholderer slightly modified both paradigms to capture participants' motivational approach–avoidance tendencies by applying “approach” and “avoidance” as attribute dimensions in both measurements (m-IAT-RF and m-IAT). In their article, they describe two empirical studies that were conducted in a consumer context, involving common consumer products (i.e., gummy bears and salty licorice) as the target dimension. In Study 1 ($n=162$), the authors evaluated the convergent and discriminant validity of the m-IAT and m-IAT-RF with respect to self-report measures of motivation and evaluation and their predictive validity with respect to actual behavior. In Study 2 ($n=205$), they compared the validity of the m-IAT and m-IAT-RF to the validity of evaluative variants of the same test paradigms (e-IAT-RF and e-IAT). In all comparisons, both procedures performed similarly. In Study 2, procedures based on the IAT-RF were superior, and the motivational IAT-RF showed the highest predictive validity with respect to actual behavior and had satisfactory convergent and discriminant validity.

To investigate the validity of the modified indirect measurement procedure of motivational approach tendencies (m-IAT-RF) further, Kraus and Piqueras-Fiszman (2016) applied and compared it with a standard evaluative version (e-IAT-RF), while participants' motivational tendencies were manipulated. Specifically, Danish students ($n=108$; 68 women and 40 men) who had no eating disorders, were nonvegetarian, and had not consumed any food 4 h prior to the experimental session, were invited to the study, which was covered as two separated experiments conducted on two different computer workstations (see Fig. 9.4). At first, all participants unwrapped, smelled, and explicitly rated the two foods (i.e., a sandwich and sweets)

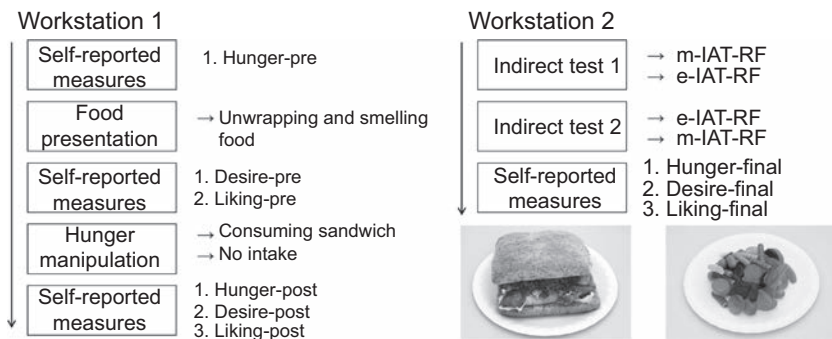


FIGURE 9.4 Illustration of the study procedure and order of the various tasks in the experiment. Numbered steps mean that the subjects performed them sequentially; steps with arrows mean that they performed either one or the other. Pictures show the two food products used in the study. *e-IAT-RF*, evaluative recoding-free implicit association test; *m-IAT-RF*, motivational recoding-free implicit association test.

in terms of their general liking and their desire to eat them at that moment. Then, all watched a video clip, while their level of hunger was manipulated: half of the participants were allowed to eat the sandwich but not the sweets when watching the clip, while the other half was not allowed to consume any of the foods. The group that was able to reduce their hunger and eat the sandwich was told that the study explored “how chewing motions affect perception and memory,” while the second group that was not eating anything was told that the study explored “how the presence of food affects perception and memory.” After this manipulation, participants were asked to rate their liking and their desire to eat the foods again. Finally, the participants were asked to move to the second computer workstation where they all completed the two indirect measurements (i.e., m-IAT-RF and e-IAT-RF) in a randomized order. Throughout the study, participants rated their general hunger, which was used as a manipulation check.

It was hypothesized that a valid measure (direct and indirect procedure) should show an interaction of food category (manipulated within participants) and desire fulfillment. Hence, explicit desire and implicit approach motivation should be higher for participants who were not allowed to consume the sandwich and fulfill their desire, compared to the group that was able to eat the sandwich during the experiment.

The results confirmed this hypothesis, and as Fig. 9.5 depicts, the m-IAT-RF successfully assessed approach tendencies toward the sandwich in the hunger group as well as approach tendencies toward the sweets in the no-hunger group (which had just eaten a sandwich). In contrast, the e-IAT-RF did not reflect a clear “preference” for any of the two popular products in either group.

In conclusion, both case studies not only described empirical studies that applied recently developed indirect measurement procedures, but also contributed to an ongoing discussion of the dissociation of motivational “wanting” and

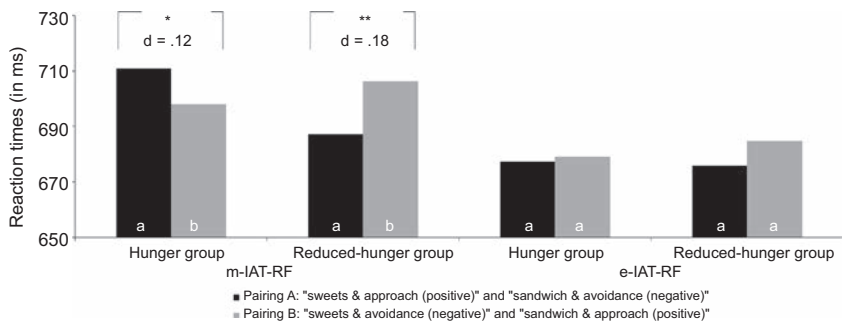


FIGURE 9.5 Mean response times for both categorization tasks in the m-IAT-RF and e-IAT-RF, separated for experimental groups. Different lowercase letters within groups and measures indicate a significant difference (at $P < .05$) according to pairwise comparisons. *e-IAT-RF*, evaluative recoding-free implicit association test; *m-IAT-RF*, motivational recoding-free implicit association test.

evaluative “liking” components of food reward, thereby trying to bridge the two research fields of behavioral nutrition and implicit social cognition.

7. CONCLUSIONS AND FURTHER RESEARCH

Throughout this chapter we have thoroughly discussed the main methodological issues around the measurement of implicit associations, particularly using the IAT. Indeed, researchers are increasingly using indirect measurement procedures to assess implicit associations and impulses, because these procedures have been shown to predict variation in behavior that is not or is only partially accounted for by explicit measures (Greenwald et al., 2009; Nosek et al., 2011). However, as mentioned earlier, the success of these indirect procedures at predicting behavior (such as choice or intake) has been shown to vary considerably across studies. The fact that behavior is successfully predicted only in some studies critically highlights that their predictive ability may well depend on several moderating variables (Frieze, Hofmann, & Schmitt, 2008).

In the food domain, some researchers have been quite critical about the added value of such measures to, for instance, uncover food likes and dislikes and to predict eating behavior and habits among specific groups of individuals. With regard to food preferences, more than a decade ago, Roefs, Werrij, Smulders, and Jansen (2006, p. 180) concluded: “In most studies, no differences in food preferences were found between obese and lean people, or between restrained and unrestrained eaters. Possibly there simply are no group differences in automatic food associations. Alternatively, the employed indirect measures are not sensitive enough to detect truly existent differences.” However, it can be argued that the presence of a food-related context is needed to find differences among individuals’ automatic food associations. As mentioned earlier, a context in which a need state is created seems necessary. The logical question is why would two equally palatable products trigger different motivations, which then lead to a specific behavior?

Various studies have demonstrated an association between implicit measures of associations and dietary-related behaviors. However, it has been suggested that implicit measures of associations may not predict dietary behaviors when taking into account the palatability of food (Ayres et al., 2012). This might mean that within the food domain researchers should apply these paradigms having considerable knowledge on the implications of their design and on the conclusions that can be drawn from observing mere, albeit strong, associations. Even with the motivational variant, recommendations have been made about including the incentive that would satisfy the current need because this contributes to the motivational quality of the implicit wanting response (Koranyi et al., 2017).

Finally, a remaining question is whether implicit associations hold throughout a long period of time and whether results actually depend on the time of measurement taken. Can researchers perform an IAT, say, on the same

participants to check the replicability of the results? Generally, test–retest reliability has been found to have mean estimates of 0.50 that ranged from 0.25 to 0.69 (Lane, Banaji, Nosek, & Greenwald, 2007), which is indeed not too satisfactory. Several explanations have been put forward to explain this discrepancy. Teige-Mocigemba et al. (2010) summarize that (1) flexible states rather than stable attitudes/traits are measured by an IAT; (2) additional sources of construct-unrelated variance, such as learning effects, attentional foci, test taking strategies, etc., could explain the low retest reliability; and (3) general context effects are important. In this regard, Gschwendner, Hofmann, and Schmitt (2008) addressed in their research the effects of concept activation on the stability of IAT scores over time. From two studies, they found that the IAT is a more stable measure; hence, its test–retest reliability is enhanced in situations in which contextual background features (such as a background picture of a snake in an anxiety IAT) activated specific construct-relevant concepts. Furthermore, this effect was particularly pronounced for respondents with chronically high accessibility for the relevant concept.

We would also like to emphasize once more that each indirect measurement procedure has its advantages and disadvantages and should be chosen based on the specific research question. All IAT variants are rather flexible and can be modified to assess different types of associations (e.g., based on evaluative, semantic, behavioral dimensions) with various kinds of targets (e.g., individuals, objects, products). However, in the end, pairs of concepts are compared. This shall not necessarily be seen as a limitation but it may prevent practitioners from applying such techniques in the “real” world. In a market research context, for instance, it rarely happens that there is only one competing product or brand that could be used as the contrasting category; often, a variety of brands, products, and choices are available. Consequently, the overall task structure of an IAT is comparative, which leads to relative results. A number of single-concept paradigms have to circumvent the relativeness of IAT results (see Sections 4.3 and 5.1.2) and even measure multiple target objects (Bluemke & Friese, 2008). Finally, a general drawback of most of the indirect measurement procedures is their total duration. In the studies performed by the authors it took approximately 12 min to perform an IAT-RF and somewhat less (10 min) to finish an IAT. Generally, these durations seem limiting, especially in applied settings. However, reducing the number of practice and test trials could affect the reliability of the mean response time.

It is our hope that the reader has gained a better understanding on how to assess implicit associations by using the standard IAT and its variations, their advantages and disadvantages, and the caveats raised in this chapter. From our perspective, the most important point to consider is that the use of implicit associations and their impact on behavior is relevant when the research question requires alternative approaches to direct procedures; that is, in circumstances in which the individuals are not able to articulate, or might not even be aware of, said associations.

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Chapter 10

Automatic Facial Expressions
Analysis in Consumer Science

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1. INTRODUCTION

The aim of this chapter is to discuss automatic facial expression analysis (AFEA) as a means of emotion measurement, with the main focus on its practical application in consumer research. Although techniques of AFEA have been under development for several decades, only recent developments have initiated the transition from basic scientific research to applied research in consumer science. However, as does every new technology, AFEA faces several limitations and considerations, which will be discussed together with case studies focusing on methodical aspects.

Despite extensive consumer testing before market introduction, the flop rate of new food products is still high. This indicates that traditional methods are not able to sufficiently predict market performance and that long-term consumer acceptance of products is not adequately captured by these methods alone (Köster, 2009; Köster & Mojet, 2007; Rozin, 2007). To gain deeper insights into consumer behavior, the measurement of emotions has rapidly increased in the last decade, as emotions significantly affect behavior. Spinelli and Monteleone discuss general aspects as well as the importance and application of emotional responses to products in detail in Chapter 11 (Volume 1) of this book. Most methods used to measure emotions in consumer research rely on self-reports. However, growing evidence shows that consumers' choices in real life are often driven by unconscious mechanisms rather than conscious and rational ones (Dijksterhuis & Smith, 2005; Köster, 2009). Therefore, methods to analyze emotions in an implicit way would seem to be beneficial. De Houwer and Moors (2007) defined an implicit measure as "a measurement outcome that reflects the to-be-measured construct by virtue of processes that have the features of automatic processes. Automatic processes on the other hand, have been characterized as unconscious, unintentional, uncontrollable, effortless and fast". To reduce response and rationalization biases, a wide range of methods such as analysis of facial expressions (Ekman & Friesen, 1978), speech (Schuller, Rigoll, & Lang, 2004), physiological parameters (Alaoui-Ismaïli, Robin, Rada, Dittmar, & Vernet-Maury, 1997), and brain images (Damasio et al., 2000) exist as possible alternatives or additions to conventional self-reports to analyze emotional responses.

Facial expressions play a very important role in our lives. Although people are generally not consciously aware of most aspects of nonverbal communication, it is the primary channel for expressing and communicating emotions (Burgoon & Hoobler, 2002). Facial expressions are often considered to provide the richest information of nonverbal communication (Ekman, 2003). Twenty anatomically independent muscles in the face allow a wide array of facial behaviors (Fig. 10.1). It has been suggested that the main purpose of some of these facial muscles is communication. They are some of the only striated muscles in the human body that are attached to bone on one side and skin on the other (Hwang & Matsumoto, 2016b). Furthermore, there are also facial muscles that are not attached to bone at all. Additional muscles on the head are responsible for jaw and neck movement (Hwang & Matsumoto, 2016b), allowing a wide range of meaningful facial and head movements.

In our everyday life we are constantly interpreting the facial actions of people we are interacting with. This process is almost automatic, e.g., without any effort we know if the boy at the next table likes or dislikes his broccoli only by watching his face during consumption, or if someone is pleasantly surprised

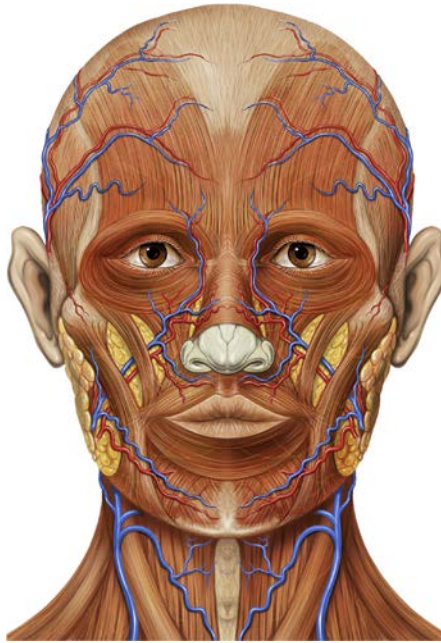


FIGURE 10.1 Anatomy of the facial muscles. (Reprinted under Creative Commons Attribution 2.5 License 2006, Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist. <http://creativecommons.org/licenses/by/2.5/>.)

or disappointed by a present. However, quantifying and objectively describing facial expressions is far more difficult.

It is widely acknowledged that spontaneous facial expressions are closely linked to emotions; and there is a long tradition of research investigating the relationship between emotions and the activation patterns of facial muscles, dating back to Charles Darwin, who discussed in his well-known book *The Expression of the Emotions in Man and Animals* (1872) an evolutionist approach to facial expressions, stating that all people, regardless of race or culture, should express emotions in the face (and body) in a somehow similar way. Famous supporters of his ideas are Carroll Izard and Paul Ekman, who refined and elaborated his evolutionist claims (Ekman, 1992c; Izard, 1971, 2009). For a review on the perspective of the evolutionist approach to emotion and facial expression see Matsumoto, Keltner, Shiota, O'Sullivan, and Frank (2008). Paul Ekman also coined the term “basic emotions.” These “basic emotions”, which are based on the evolutionist theory, are distinct universal emotions comprising anger, disgust, fear, happiness, sadness, and surprise (Ekman, 1992a, 1992b; Ekman & Cordaro, 2011). A recent study from 2016 showed that there is high agreement among scientists researching emotion on the six stated basic emotions (Ekman, 2016).

There is still an ongoing discussion on the cognitive influences and socially learned interpretations of emotions. Several studies indicate that a number of “basic” facial expressions are innate and universal, e.g., showing that neonate infants, only hours after birth, without previous experience in food intake whatsoever, displayed distinct facial expressions when exposed to basic taste solutions (Ganchrow, Steiner, & Daher, 1983; Steiner, 1974). For an extensive review on the current perspectives on infant emotions and facial expressions see Camras and Fatani (2008). Furthermore, those studies illustrate that facial expressions are a natural and very intuitive way to express preferences. Of course this code of expressing emotions and preferences could develop only if other humans were able to decode the facial actions reasonably well, and in fact, humans are perfect experts in decoding facial expressions. A study by Matsumoto and Willingham (2009) investigated spontaneous facial expressions of blind individuals and found that blind, noncongenitally blind, and sighted individuals displayed very similar facial expressions. These findings provide evidence that spontaneous facial expressions of emotion are not dependent on observational learning. However, there is also growing evidence challenging the concepts of “basicness” and “universality” of emotions [interested readers are referred to Feldman Barrett (2016) for a critical review].

A different way to classify emotions are dimensional models, as opposed to discrete “basic” emotions. Although less represented in the literature, they have a long history (Schlossberg, 1952). Most of the dimensional models, including the well-known circumplex model developed by Russell (Russell, 1980), classify emotions in two dimensions; valence (pleasant–unpleasant) and activation or arousal (high–low), see Fig. 10.2. Several studies found that emotions and facial expressions can be reliably rated using those two dimensions, indicating that facial actions support the two very basic reactions to stimuli: approach or avoidance (Greimel, Macht, Krumhuber, & Ellgring, 2006). This is probably also a reason facial expressions are often interpreted as positive or negative affect (Oster, 2005). Furthermore, Barrett (2006) claims, in her review, that the valence dimension is of particular importance to emotional responses.

The definition of and the relationship between emotions and bodily responses were, and still are, subject to considerable debate; however, for the purpose of this chapter we use a broadly accepted and very general definition of emotions to differentiate between the three different types of affective behaviors: (1) evaluative attitudes (e.g., “I like steak”), (2) slower forming but more enduring moods that are not focused on a specific object or event (e.g., “I am happy”), and (3) emotions that are usually brief and intense and focus on a specific stimulus or event (e.g., “Reading today’s news made me feel sad”) (Clore, Ortony, & Foss, 1987; Ferrarini et al., 2010; King & Meiselman, 2010). For a review see Spinelli and Monteleone (Chapter 11, Volume 1 of this book) or Izard (2009).

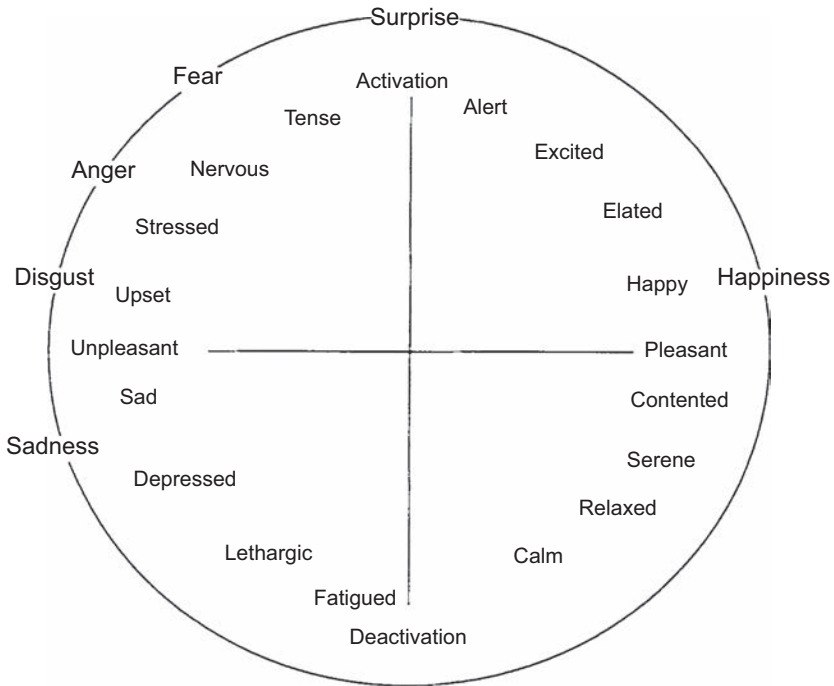


FIGURE 10.2 Circumplex model by Feldman Barrett and Russell (Feldman Barrett & Russell, 1998; Russell & Barrett, 1999). The inner circle shows a schematic map of core affect. The outer circle shows where several prototypical/basic emotions typically fall. (Copyright 1998/1999 by the American Psychological Association.)

2. ANALYZING FACIAL EXPRESSIONS

Irrespective of whether facial expressions are analyzed by humans or by means of a software algorithm, two different approaches can be distinguished: (1) anatomically based measurement and (2) judgment methods (Wagner, 1997). Anatomically based methods such as the facial action coding system (FACS), the maximally discriminative facial movement coding system (MAX), or facial electromyography (EMG) analyze the activity of certain facial muscles or muscle groups and, based on the activation pattern, try to classify the measured facial behavior into certain emotions. Judgment methods classify facial expressions directly as emotions or grounded on the dimensional theory of emotions as valence and activation/arousal, based on observer judgments. Although most commercial automatic facial expression systems can evaluate certain facial muscle activities, or action units, based on FACS, their analysis algorithms for emotions are often not anatomically based, but instead attempt to directly map facial expressions as emotions (Fasel & Luetttin, 2003).

One of the many challenges facial expression analysis has to face is that spontaneous facial expressions are typically brief and regularly last only a few seconds, but rarely less than 250ms or more than 5 s (Ekman, 1992a; Fasel & Luettin, 2003). Furthermore, facial expressions can occur in fast sequences and overlap with one another or with other facial behaviors, like movements caused by speaking, chewing, drinking, etc.

2.1 Anatomically Based Measurement Methods to Analyze Facial Expressions

In the following section, the different anatomically based methods are described briefly as they are important to understanding AFEA and its advantages and disadvantages. Readers who are especially interested in anatomically based measurements are referred to Hwang and Matsumoto (2016b), who provide a more detailed overview of these methods.

The FACS developed by Ekman and Friesen (1978) is probably the best known and most commonly applied method in facial expression research. FACS is an anatomically based system to describe and measure facial behavior. The system builds on 44 action units (AUs), which are defined as independent movements of facial muscles or muscle groups. Using these 44 AUs any facial behavior can be described, no matter if it is a facial expression of emotion or of a chewing gum. Based on activation patterns it is possible to identify and describe the emotions associated with the facial behavior.

The development of FACS boosted the analysis of facial expressions. Additionally, abbreviated versions of FACS have been developed. Emotions FACS uses only a subset of AUs, which has been related to the expressions of basic emotions, to increase analysis speed or systems especially designed to analyze facial expressions of children, e.g., the MAX (Izard, 1979).

Although FACS and many of the other systems have shown their reliability in research, these methods also have downsides limiting their application in “everyday” consumer research. First of all, the analyses are very laborious and time consuming, and furthermore the quality of the analyses is highly dependent on the coders and how well they are trained.

Another anatomically based method is facial EMG. This technique is capable of detecting subtle changes in muscular activities of the face that are unlikely to be recognized with observational techniques (Hu et al., 1999). Although the methods are very sensitive compared to observational methods, the detection region is diffuse and therefore it is often not possible to differentiate between the activities of single muscles in one area. Furthermore, the application of electrodes on the face can be regarded as very intrusive, especially if social interactions in natural settings are investigated. The physical attachment of electrodes to the face also limits the number of muscles being monitored, as only a certain number of electrodes can be attached at the same time.

2.2 Judgment Methods to Analyze Facial Expressions

Judgment methods do not analyze the activity of individual muscles or muscle groups. Instead, observers directly judge the expressed emotion using emotion categories or scales. These methods capture the communication or signal value of facial expressions, but do not describe the facial behavior in detail and may bear the risk of missing subtle differences between expressions or facial behaviors that are not associated with the scored emotions. A special case of these holistic analysis methods is the facial expression coding system FACES (Kring & Sloan, 2007). FACES is based on the dimensional model of emotion and analyzes facial expressions regarding their valence and duration. This simplifies the coding process even more as coders only need to classify a facial expression as positive or negative and rate the intensity of the expression on a 4-point Likert scale.

The advantage of judgment methods is that they are less laborious and less time consuming and, for most applications, coders require less intense training compared to anatomically based systems like FACS. As a trade-off less detailed data are collected and subtle differences may be missed. For example, it is very likely that both Duchenne and non-Duchenne smiles will be classified as happy, joy, or pleasant emotion, although only the Duchenne smile should be associated with enjoyment, whereas non-Duchenne smiles have social regulatory functions, such as masking other facial expressions (Ekman, 1992a, 1994; Frank, Ekman, & Friesen, 1993).

2.3 Automatic Facial Expressions Analysis

While there is a wide range of automatic analysis systems available, most research and commercial solutions share a similar generic framework to classify facial expressions (Fig. 10.3):

1. Face acquisition: identification of the face and its position, outline, and orientation in an image or video frame.
2. Facial feature extraction: a multitude of methods can be used for feature extraction; however, in general two approaches can be used: processing the face holistically as a whole or focusing on specific areas of the face that have been identified as important for facial expressions.
3. Facial expression classification: using statistical models (classifiers), facial expressions can be either classified using an anatomically based coding scheme or directly classified as emotion using a judgment approach. These classifiers are trained using hundreds or thousands of manually annotated pictures and can classify facial expressions as emotions or activity of selected AUs or describe facial expressions in a more holistic way, e.g., based on valence or arousal as described by the circumplex model.

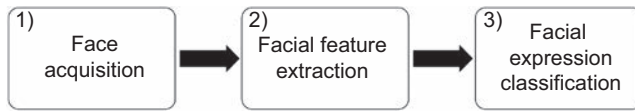


FIGURE 10.3 Simplified generic framework to classify facial expressions.

Readers specifically interested in the technical and mathematical aspects of facial expression analysis are referred to [Fasel and Luettin \(2003\)](#), [Tian, Kanade, and Cohn \(2005\)](#), or [Zeng, Society, Pantic, and Member \(2009\)](#), as a detailed discussion would exceed the scope of this chapter.

All AFEA methods have in common that they are highly dependent on high-quality pictures or video recordings. Although more robust methods have been developed, special care needs to be taken regarding recording resolution, lighting, focus, head orientation, etc. Depending on the method used, partial occultation of the face by hairstyles, sample handling, or gestures may potentially bias the results. Also glasses, especially with thick frames covering the eyebrows or reflections in the lenses, negatively influence AFEA performance. However, cameras with polarization filters can be used to minimize the negative effects of reflections.

Using AFEA a multitude of facial expressions and features can be extracted from pictures or video recordings, including quality and intensity of expressed emotions, activity of AUs, state of specific facial features (e.g., eyes open/closed, eyebrows raised/neutral/lowered), head orientation, and gazing direction. For practical application it is important to decide which information is required to choose the most suitable classifier for the analysis.

Although automated systems to analyze facial expressions have been under development for a long time, commercial solutions for consumer research have been available only for several years. These software solutions provide additional features, e.g., basic video editing and potential to mark sections of interest or specific events, synchronize data from multiple sources, and visualize results, therefore improving usability and throughput as well as approachability for researchers from different fields of research. Using commercial AFEA solutions is especially interesting to researchers who are looking for a user-friendly, reliable, and quick way to analyze facial expressions.

3. CONSIDERATIONS WHEN USING AUTOMATIC FACIAL EXPRESSION ANALYSIS

Despite the fast advances in the field of AFEA in the past decades, there is still an ongoing dispute about their application. In the following we will discuss some advantages as well as limitations of AFEA compared to the conventional facial expression analysis methods using human coders or judges.

3.1 General Consideration When Using Facial Expression Analysis to Measure Emotions in the Field of Consumer Science

Analysis of facial expression is a promising methodology to measure emotions in an implicit and unobtrusive way. However, scientists and consumer researchers need to take several general considerations into account when choosing the most suitable methodology for their study.

The basic requirements are high-quality video recordings of the face for subsequent analysis. In a controlled laboratory setting this is not a big issue, because modern cameras, camcorders or even webcams built into regular laptops can deliver pictures or videos of sufficient quality and are very affordable (Danner, Sidorkina, Joechl, & Duerrschmid, 2014). However, outside the laboratory things can get more complicated, e.g., participants can move freely, lighting conditions change, and hairstyles, sunglasses, and clothes (e.g., scarves) cover important facial features, just to name a few. Other facial behaviors not related to the expression of emotions, like talking, chewing, or drinking, potentially influence the results as well. In addition to technical issues, legal issues also need careful consideration, especially when applying AFEA in public or commercial space. Interested readers are referred to Lewinski, Trzaskowski, and Luzak (2016) for a review of face and emotion recognition on commercial property under EU data protection law; however, even within the EU legislation can differ significantly.

Another important consideration is the number of analyzed emotions. Most facial expression analysis methods are capable of classifying facial expressions as a small number of prototypical expressions of emotions. Hwang and Matsumoto (2016a) concluded in their review that there is strong evidence for the expression of seven emotions: anger, contempt, disgust, fear, happiness, sadness, and surprise. This is considerably fewer compared to self-report surveys, which often assess between 15 and 40 emotion terms (Bhumiratana, Adhikari, & Chambers, 2014; Danner et al., 2016; King & Meiselman, 2010; Nestrud, Meiselman, King, Leshner, & Cardello, 2016). However, depending on the aim of the study a low number of emotional terms or a two-dimensional model might be sufficient or even desired, especially when taking into account that, despite the high number of emotions used in studies with questionnaires, most of the variance in emotional data can often be explained in only two dimensions (Chaya et al., 2015; Nestrud et al., 2016; Ng, Chaya, & Hort, 2013).

A very general consideration, not solely related to AFEA, is the expected intensity of elicited emotions by the studied samples and also the expected differences in emotion intensity between samples. Although more and more research is conducted using everyday food products, it is still not clear how sensitive AFEA is and how big the emotional differences need to be to be detected.

Furthermore, it is difficult to provide a clear recommendation, as emotional responses depend on a multitude of factors including expectations, personal traits, context, etc., aside from the intrinsic and extrinsic attributes of the product. The analysis of microexpressions/reactions might provide an increased sensitivity. However, in general if the expected emotional responses are very weak or the expected differences between the samples of interest are only very small, other methods than AFEA might be more suitable.

3.2 Advantages of Automatic Facial Expression Analysis

The primary advantage of AFEA is the very fast throughput. AFEA is much faster and less labor intensive and, therefore, in most cases far more cost effective compared to conventional facial expression analysis with human coders, which is performed by postprocessing video recordings in slow motion or frame by frame and coding facial expressions based on predefined rules. Furthermore, if anatomically based methods are used, coders need to undergo extensive training to learn the method. In comparison, modern automatic analyses are capable of processing recordings in real-time or even faster.

In theory human intervention is limited and therefore, potential biases of coders, who might be aware of the design of the experiment, context, etc., are eliminated by the use of automatic analysis. However, in real-life situations human intervention is still often required, for example, for quality control (was the expression caused by the stimuli or was the person just sneezing?), to identify the context of social interactions, or for selecting the sections of interest (e.g., tasting sample or interacting with product). Therefore, potential biases cannot be eliminated completely.

Possibly the main advantage of AFEA and other unobtrusive observational methods compared to self-reports is the potential increase in ecological validity. “Ecological validity of a study means that the methods, materials and setting of the study must approximate the real-world that is being examined” (Brewer, 2000). The use of AFEA allows real-time analysis of facial expressions in real-life situations without interfering with the subject or the subject’s behavior; therefore, such studies can be regarded as high in ecological validity. In comparison, answering a questionnaire often interferes with the behavior or task of interest, or it is completed retrospectively and therefore is potentially biased by a multitude of cognitive processes, such as considering social desirability, resulting in potentially lower ecological validity.

3.3 Limitations

Despite the latest advances and improvements, AFEA is far from being perfect and faces several limitations that need to be taken into consideration when using it, planning experiments, comparing different methods to analyze emotions, or interpreting results derived from AFEA.

The major concern about AFEA is the validity of the results. Numerous studies showed that AFEA systems can achieve high accuracy in the classification of emotion and activation of specific AUs (Tian, Kanade, & Cohn, 2001) or facial features. For a review see Zeng et al. (2009), who summarized 32 studies investigating the accuracy of AFEA classifiers. In 19 of the 32 studies the AFEA classification accuracy exceeded 80%.

Studies investigating the accuracy of commercially available solutions are scarce in the scientific literature. We found only one peer-reviewed publication investigating the accuracy of the FaceReader software (Lewinski, den Uyl, & Butler, 2014). In this study FaceReader achieved an accuracy of 88% on average (ranging between 76% for anger to 96% for happiness) when classifying six basic emotions in two emotion data sets (Warsaw Set of Emotional Facial Expression Pictures and Amsterdam Dynamic Facial Expression Set). In comparison human coders achieved 85% accuracy on average. In the same study the FaceReader software achieved a FACS index of agreement of 0.67 overall (the performance varied hugely across the classified AUs, ranging from 0.22 for AU 10 up to 0.92 for AU 25). In contrast a human coder must reach an agreement of 0.70 with the master coding to pass the final test. However, only very little is known about the validity in real-life situations or across ethnic groups.

As previously discussed, all AFEA methods greatly depend on high-quality pictures or video recordings. Although modern systems can handle variations in lighting conditions, head orientation, partial obscurities of the face, facial hair, or glasses to a certain degree, it is unknown how these variations may influence the validity of the results.

To ensure internal validity, the training and test data must be coded manually and the reliability of the coding has to be verified. However, a very general problem for all AFEA methods is the reliability of the ground truth. When training a system to classify facial expressions, the investigator assumes that training and test data are accurately labeled. This assumption may or may not be accurate; especially if spontaneous real-life data are used, even human coders or judges do not always agree completely. Many data sets are derived from asking subjects to perform a given action; however, this is no guarantee that the subjects will do that properly and it also not clear that posed expressions reflect spontaneous expressions. On the other hand, when using spontaneous expressions, it is often unknown exactly what the subject felt in a specific moment.

4. SELECTED STUDIES APPLYING AUTOMATIC FACIAL EXPRESSION ANALYSIS IN THE FIELD OF CONSUMER RESEARCH

AFEA has a wide range of potential applications in the field of consumer research, ranging from advertising to product testing to online shopping behavior, to name just a few. In this section, we introduce selected empirical studies applying AFEA to detect and classify facial expressions. We will start with

describing one of our initial studies in detail, followed by a broad overview of studies investigating different aspects in consumer research.

4.1 Emotional Responses Related to Food Consumption

There are numerous studies demonstrating that tastes and odors elicit different facial reactions in neonates (Rosenstein & Oster, 1988; Soussignan, Schaal, Marlier, & Jiang, 1997; Steiner, 1974), children (Soussignan, 1996; Zeinstra, Koelen, Colindres, Kok, & de Graaf, 2009), and adults (Greimel et al., 2006; Hu et al., 1999; Wendin, Allesen-Holm, & Bredie, 2011). In most of these studies rather intense stimuli were used, including concentrated basic taste solutions (Wendin et al., 2011) or odors ranging from fruity to fecal (Soussignan, 1996). Only recent research has investigated real-life commercial samples (Danner, Haindl, Joechl, & Duerrschmid, 2014; Danner, Sidorkina, et al., 2014; Kostyra et al., 2016; Mojet et al., 2015; de Wijk, Kooijman, Verhoeven, Holthuysen, & de Graaf, 2012).

4.1.1 Case Study

Our initial study (Danner, Sidorkina, et al., 2014) investigated how tasting different orange juice samples influenced participants' facial expressions in an implicit and explicit measuring approach. The aim of the implicit approach was to examine whether tasting different juices elicits different spontaneous facial expressions in participants who were not aware that they were being video recorded and their facial expressions analyzed. For the explicit approach, participants were asked to express how much they liked or disliked the tasted sample and express their liking with a posed facial expression into the camera. The aim was to investigate whether AFEA can be used to discriminate between samples using intentional facial expression of liking or not. In total, six different orange juices available on the Austrian market, including diluted syrup (diluted following the manufacturer's guidelines), nectar, 100% juice, and NFC (not from concentrate) juice, were used as test stimuli. Seventy-eight students participated in the implicit and 75 in the explicit measurement approach.

FaceReader version 4 software from Noldus Information Technology (Wageningen, the Netherlands) was used to analyze the spontaneous and the posed facial expressions based on the video recordings frame by frame. FaceReader is capable of detecting six basic emotion patterns, including angry, happy, disgusted, sad, scared, and surprised, and a neutral expression using pictures or video footage of faces. Online/real-time as well as offline/postprocessing frame-by-frame analyses are possible. The software works in three steps (Noldus Information Technology, 2012), following the generic framework discussed earlier (Fig. 10.3):

1. It finds the position of the face in an image using a Viola–Jones cascaded classifier algorithm (Viola & Jones, 2004).

2. It performs facial modeling using the Active Appearance Model (Cootes, Edwards, & Taylor, 2001) to synthesize an artificial face model, which is based on the locations of 500 key points in the face and the facial texture of the area entangled by these points. Fig. 10.4 shows an example of the three-dimensional mesh with the 500 key points produced by the face modeling algorithm.
3. It classifies the face as angry, happy, disgusted, sad, scared, surprised, and neutral. The intensity of these emotions is scaled from 0, not present at all, to 1, maximum intensity of the expression based on the model used (van Kuilenburg, Wiering, & den Uyl, 2005). The classifier was “trained” with over 10,000 manually annotated images.

The recordings of approximately 75% of the participants were suitable for facial expression analysis using FaceReader software. The main reasons for disqualification were: participants did not face the camera after tasting the samples, hairstyle covered too much of the face, or the participants rested their chin on their hands and hence meaningful analysis of their facial expressions was not guaranteed. In the case of the implicit measurement approach the spontaneous facial expressions directly after tasting 30 mL of the sample were analyzed. For the explicit measurement participants were asked to visualize the taste experience of the sample with an intended/posed facial expression best representing their liking of the sample after tasting it.

For the statistical analysis a within-subject design using repeated-measures analysis of variance (RMANOVA) was used. As facial expressions have a quick onset (they can begin in a matter of milliseconds after



FIGURE 10.4 Example of how FaceReader software produces and visualizes the three-dimensional model of a face using 500 key points.

an emotion-provoking stimulus) and a brief duration (matter of seconds) (Ekman, 1992a), we decided to use the maximum intensity values of the facial expression patterns.

The results of the RMANOVA showed that AFEA using FaceReader software is a sufficiently accurate method to differentiate between various orange juice samples in the implicit as well as the explicit measuring approach. In the explicit measurement, a clear discrimination between liked, neutral-rated, and disliked samples was possible on the basis of the intensity of the posed facial expressions of “angry,” “disgusted,” “happy,” and “neutral,” resulting in a discrimination similar one based on hedonic ratings. Using the implicit measurement approach only the least-liked sample (syrup) could be discriminated from the other samples based on spontaneous facial expressions directly after tasting. This supports the findings of Zeinstra et al. (2009), who found similar results using human FACS coders and concluded that implicit facial reactions are suitable measures for dislike, but not necessarily for liking. An important finding in the case of the implicit measurement is that, although the majority of participants showed clearly detectable changes in facial expressions, approximately 25% showed very little to undetectable changes in facial expressions over the course of the experiment.

However, when not only comparing facial reactions elicited by samples but also considering the individual liking ratings, a moderate to strong correlation between liking and implicit facial expression (see Fig. 10.2) was observed. The intensity of “angry” and “disgusted” was negatively correlated with liking and a “neutral” facial expression was positively correlated with liking. This finding implies that the absence of expression of negative emotions is an indication of liking. No correlation between liking and expression of positive emotion, in this case “happy”, was observed for spontaneous facial expressions. Similar results were also found by de Wijk et al. (2012), who found that disliked food products evoked more intense changes in facial expressions compared to liked products. The opposite was true for the explicit measurement approach, in which posed facial expressions of “happy” were a clear indicator of liking, indicating the high communicative value of smiles.

4.1.2 Temporal Effects

The measurement of facial expressions is capable of capturing temporal information about a person’s emotional experience. The unfolding of emotions can provide deeper insights into the evaluation process itself and the formation of preferences. In the following we present two studies that investigated the temporal dynamics of facial expressions in tasting situations. He, Boesveldt, de Graaf, and de Wijk (2016) investigated the relationship between continuous and discrete emotional responses to food odors using AFEA methodology. Their results showed that facial expressions varied dynamically following the stimuli, in that expressions at 1250ms onward were most strongly related to odor valence, and around 2000ms following the stimuli were best correlated

with odor intensity. Furthermore, some facial expressions of emotions such as disgust and sad reached their maximum relatively early compared to angry and happy.

A study by Rocha-Parra et al. (Rocha-Parra, García-Burgos, Munsch, Chirife, & Zamora, 2016) took the dynamic measurement one step further and investigated temporal effects using a multi-sip approach. They found that emotions independent of valence showed a decrease from the first to the third sip; however, this decrease was substantially larger for emotions of negative valence. This result matches very well with the simultaneously assessed temporal liking, which increased from the first to the third sip.

4.2 Applications of Automatic Facial Expression Analysis in Advertising Research

Another promising application field of AFEA is advertising. It has been shown that emotional advertisements are more likely to be remembered; they attract more attention and therefore may be more successful (Ambler & Burne, 1999). Furthermore, the measurement of emotional responses using analysis of facial expressions was found to deliver good predictors for the strength of recalling a commercial (Hazlett, Richard L, Yassky Hazlett, 1999), skipping behavior (Teixeira, Wedel, & Pieters, 2012; Yang, Kafai, An, & Bhanu, 2014), advertisement liking, and purchase intent (McDuff, Kaliouby, Cohn, & Picard, 2015).

Lewinski, Fransen, and Tan (2014) analyzed the facial expressions of 90 participants while watching six amusing video advertisements using FaceReader 5.0 (Noldus Information Technology) software. Their results show that the intensity of evoked facial expressions of happiness was highly correlated with self-reported advertisement amusement assessed in a pretest. Furthermore, they showed that the intensity of happy facial expressions assessed by AFEA was highly correlated with increased advertisement effectiveness, assessed by attitude toward ad and attitude toward brand.

A more recent study by McDuff et al. (2015) took this approach to the next level and analyzed over 12,000 responses from 1223 people watching a total of 170 online video ads from four countries to predict ad liking and purchase intent. In total, they analyzed 3.7 million frames of video material and classified eyebrow raises, smiles, disgust expressions, and expressions of positive and negative valence. Clearly, analyses to this extent are hardly feasible with traditional methods using human coders. To achieve the high number of participants, data were collected online using participants' own webcams. This approach bears the advantage that participants were in a natural and familiar viewing context and environment rather than in an unfamiliar laboratory setting. The results showed that advertisement liking and change in purchase intent can be predicted accurately by analyzing facial expressions. Furthermore, they concluded that peak positive responses directly followed by a brand appearance are more likely to effectively influence purchase intent.

5. DISCUSSION AND FUTURE DIRECTIONS

Advances in machine learning, resulting in more robust AFEA systems, together with the development of user-friendly commercial software solutions, open up numerous new applications of facial expression analysis in consumer research by substantially increasing analysis speed and at the same time reducing costs compared to traditional methods using human coders or judges. This development also propels the transition from controlled experiments in the laboratory to more real-life situations. The increased interest in facial expressions as a means of human–computer interaction potentially accelerates future developments even more. Recently Apple, Inc., bought the artificial intelligence startup Emotient, Inc., whose technology assesses emotions by reading facial expressions, and Microsoft Corporation has developed its own Emotion API, which can be used in a wide range of software applications. This clearly shows that AFEA is transforming from primarily scientific to more mainstream applications.

Despite all the advances AFEA still faces several challenges. Although it has been shown that AFEA can achieve high accuracy or high agreement with human coders, the validity of the results of AFEA is still a main concern, especially in real-life situations. Furthermore, obtaining reliable ground truth to train AFEA classifiers is still problematic, as only a very small number of emotions are well defined in the literature and often agreement among human coders is also mediocre.

In an opinion paper, [Gunes and Hung \(2016\)](#) raised the question of whether automatic facial expression recognition of emotions is coming to a dead end. In their opinion, recognizing Ekman's "basic" emotions under clear conditions is now solved. However, although more and more elaborate and complex machine learning and computer vision approaches are being developed to classify facial expressions as emotions, the fundamental problem is that the small number of Ekman's "basic" emotions, no matter how accurately measured, provide only limited information, and research focuses too little on new and innovative approaches, e.g., continuous and dimensional models. One of their suggestions is to move from vision-only to multimodal emotion-sensing approaches. Combining additional measures of speech, heart rate, galvanic skin response, gazing behavior, etc., together with the transition from controlled to real-life situations might allow deeper insights into the emotional states of participants. The good news is that current development is starting to pick up on those general concerns and is intensively working on combining different measures. State-of-the-art commercial AFEA solutions can additionally analyze gazing directions and classify emotions using basic dimensional models. They are compatible with biofeedback devices allowing the simultaneous measurement of body reactions, including skin conductance, heart rate, and skin temperature, or even allow the extraction of the participant's heart rate from the video recording using remote photoplethysmography ([McDuff, Estepp, Piasecki, & Blackford, 2015](#); [Tasli, Gudi, & den Uyl, 2014](#)).

Ahn, Bailenson, Fox, and Jabon (2011) suggested another interesting and also very promising approach. Instead of taking the route of classifying emotions or facial features to understand and predict behavior, they suggest using raw facial movement data to directly predict behavior. Classifiers are not limited to detecting facial expressions of emotions. Instead, they could potentially be used to directly predict behaviors, including product choice, increased willingness to pay, intention to try, operator fatigue, etc. (Ahn et al., 2011). Such an approach could take AFEA away from the difficult and also often limited (in terms of number of emotions analyzed and general relationship between facial expressions and emotions, to name just a few previously discussed limitations) interpretation of how emotions influence human behavior and bring it to the next step, predicting behavior in a direct way. However, future research needs to investigate the feasibility and potential accuracy of such direct approaches.

In conclusion, analysis of facial expressions using AFEA offers researchers an unobtrusive and fast method of potentially high ecological validity to investigate consumers' emotions. Although the application of AFEA is relatively new in consumer research, partially caused by limited availability of robust commercial solutions, the increasing interest of big IT players like Apple, Inc., and Microsoft Corporation in AFEA might propel future development and broaden the possible applications of AFEA. However, even with improved technical possibilities, it is important for a researcher to carefully plan experiments and take the previously discussed considerations as well as limitations of facial expression analysis in general and AFEA in particular into account. Some of the limitations can be overcome by carefully planning the study, combining AFEA with other implicit methods, or possibly by completely new ways to analyze facial expressions and behavior, as suggested by Ahn et al. (2011).

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Chapter 11

Physiological Measurements:
EEG and fMRI

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1. INTRODUCTION

As consumers, we are continually bombarded with large amounts of information. This information stems not only from our environment (e.g., advertisements aiming to influence our consumption pattern) but also from our own body (e.g., stomach telling us that it has been a while since we ate something or a memory of a sweet vanilla ice cream eliciting the urge to buy one). Understanding how we process and integrate information stemming from different sources is a necessary step towards a better understanding of how consumers behave and how this information affects our actual behavior and guides future behavior.

In general, information from our environment enters the body via our sensory organs, and the physical signals (e.g., molecules of food, light waves, or pressure changes), detected by different sensory receptors, are transduced and transmitted via our sensory nerves to our brain. The process of detecting physical information and the transmission of this information to the brain is called *sensation*. Experiencing the world around us, however, is not solely based on sensation. Our brain actively interprets the information received from our sensory organs and constructs a meaningful impression of a particular sensation. This is called *perception*. Thus, sensation and perception are distinct processes, which have to be integrated to form an experience.

How we actually experience the world is a result of how our brain processes information and actively constructs perceptual experiences based on both sensory information (bottom-up processing) and knowledge available from previous experiences stored in our memory system (top-down processing). The bottom-up processes provide specific information about physical characteristics of information or stimuli detected in our environment. Top-down processes concern the influence of our knowledge, past experiences, and expectations, which on the one hand guide attention, thereby influencing what information will enter our sensory system, and on the other hand shape the interpretation of sensory information that entered the brain. Both bottom-up and top-down processes play important roles in the interpretation of information and the subsequent selection and execution of appropriate behavioral responses.

Behavioral responses are the final product of many different brain processes elicited by both environmental (e.g., food product) and internal (e.g., hunger) stimuli. The measurement of behavior (e.g., reaction times, liking ratings) can, up to a certain extent, offer insight into ongoing cognitive operations underlying overt performance. Importantly, these measures do not provide a systematic way to investigate these processes in a more direct manner. A behavioral response might, for example, be the result of a deliberate choice between two options or the result of attending to only one of these options. We might buy an apple instead of an ice cream because we are on a diet and go for the more healthy option (deliberate choice), but on the other hand it might be possible that we did not notice the ice cream man and because we are hungry we go for the, as far as we are aware, only option, the apple (attentional limitation) (this

last option becomes less likely on a hot summer day on which attention seems to be attracted automatically to everything related to ice creams!). In addition, if we rely on behavioral measures to examine human performance, studies are limited to conditions in which overt behavior can be observed; in conditions in which no overt reactions are required, no information about information processing can be obtained.

To more fully understand how behavior is associated with sensation and perception we need research techniques that provide more direct information about ongoing processes in our brain, in addition to behavioral measures, such as scores on questionnaires or reaction times. For the remainder of this chapter we will focus on two physiological measurements that are frequently used in cognitive and sensory neuroscience to study the relation between brain processes and behavior: electroencephalography (EEG) and functional magnetic resonance imaging (functional MRI or fMRI). These techniques will be discussed in relation to processing of food information, and taste perception in particular.

2. THE NEUROBIOLOGY OF TASTE PROCESSING

Taste perception involves processing of information entering our body via all our sensory organs. We see what we eat or drink. We taste, smell, and feel the food in our mouth and we might hear sounds as we chew or drink it. This information enters via different sensory organs and is transmitted to different areas in the brain. If we focus on the perception of taste information (Fig. 11.1a), a complex network of interacting brain regions can be identified. If we, for example, take a bite from an apple, chemical substances from the apple dissolve in saliva and are received by taste receptors mostly located in the taste buds distributed on the tongue. These taste receptor cells excite afferent nerve fibers, which converge in the brain stem and synapse in the nucleus of the solitary tract (NST). NST fibers project to the ventroposterior medial nucleus of the thalamus and from here taste information is projected to the anterior insula, which is considered the primary gustatory area in the brain (e.g., Kurth et al., 2010; Small, 2010; Veldhuizen et al., 2011).

When we take a bite, we also process olfactory information. Food-related odors travel from the oral cavity into the nasal cavity (Fig. 11.1b). The receptor cells in the olfactory epithelium innervate a large collection of olfactory nerves, which synapse in the olfactory bulb. A major projection target of the olfactory bulb is the piriform cortex (also termed the primary olfactory cortex), which in turn projects to thalamic and hypothalamic nuclei, the hippocampus, amygdala, orbitofrontal cortex, but also the anterior insula (Chen et al., 2014; Johnson et al., 2000; Small, 2012; Small, Veldhuizen, & Green, 2013).

Although taste and smell are sensed by separate sensory organs, and distinct pathways relay gustatory and olfactory information to the brain, this information has to be integrated into a single percept of the specific taste of the food product we consumed. After simultaneous stimulation by gustatory and olfactory

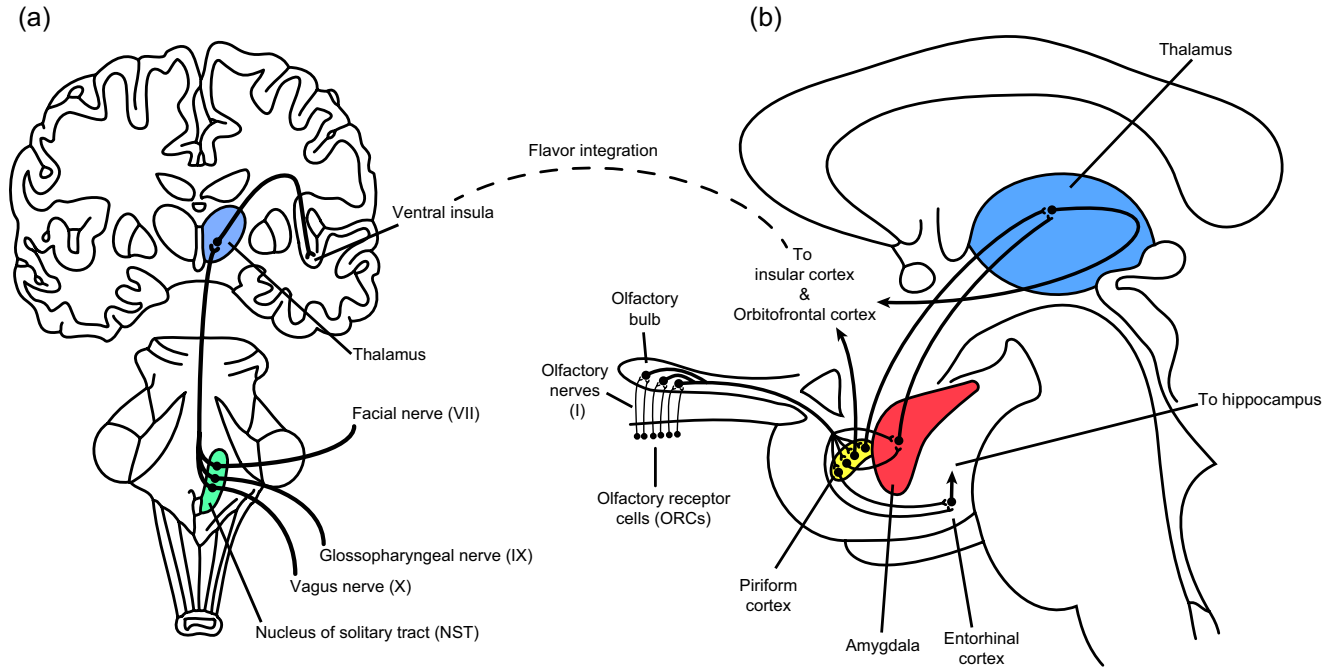


FIGURE 11.1 Neuronal pathways involved in taste processing. (a) A coronal illustration of the brain and brain stem indicating the gustatory pathway. (b) A sagittal illustration of the brain indicating the olfactory pathway. *Roman numerals* indicate the numbered cranial nerves involved.

information, the response in the anteroventral insula is greater than after stimulation by taste or smell alone, suggesting that the insula is one of the brain areas involved in the integration of gustatory and olfactory information (Small, 2012, Fig. 11.1). Thus, we are able to experience the taste of food because our sensory organs work closely together with a complex network of interacting brain regions that integrate information from different sources and/or stimuli.

3. FUNCTIONAL MAGNETIC RESONANCE IMAGING

There are multiple imaging techniques to study brain function. These techniques are based on the assumption that neuronal activity is associated with localized changes in brain physiology. A noninvasive neuroimaging technique to study brain function is fMRI. Many textbooks are available that explain the principles of fMRI (and structural imaging using MRI) and the analyses involved to produce meaningful results (e.g., Huettel, Song, & McCarthy, 2014). In this chapter we will focus on the most important terms and concepts behind this research technique and we will explain what types of questions can be answered using fMRI. Subsequently, we will explain the basic principles of fMRI (and MRI), how sensory science fMRI experiments are commonly set up, and how the data of these experiments are generally analyzed.

3.1 What Questions Can We Answer Using fMRI?

The foremost reason to use fMRI is to investigate *where* information is processed in the brain. FMRI offers better spatial precision throughout the brain over other neuroimaging methods such as EEG, positron emission tomography, magnetoencephalography, or near-infrared spectroscopy. Furthermore, fMRI also offers great possibilities to investigate how different brain areas work together in a networked environment. Various tools have been developed that allow investigating how strongly groups of brain areas are connected, and how these connections are modulated by, for example, stimulus type, homeostatic state, or health condition (e.g., Geerligs, Cam-CAN, & Henson, 2016; McLaren et al., 2012).

So far sensory science fMRI studies have primarily focused on fundamental questions about brain function and health. These studies were set up to increase our understanding of (affective) stimulus processing in relation to medical conditions. García-García et al. (2013) reviewed 86 of these studies to investigate the relation between eating disorders (anorexia nervosa, bulimia nervosa, binge eating disorder, and obesity) and neuronal activation during visual processing of food information. In addition to understanding changes in brain function associated with health status, fMRI is also indispensable for understanding and predicting consumer behavior. FMRI not only allows prediction of buying behavior, which is interesting for marketing purposes (Ariely & Berns, 2010), but also allows health-related predictions such as future weight change, which provides additional value in the context of healthy lifestyle promotion (Demos, Heatherton, & Kelley, 2012).

3.2 How Does fMRI Work?

The fMRI technique is based on the principles of MRI, a technique used to visualize the inside of the body in three-dimensional space with minimal invasiveness. MRI uses magnetic properties of hydrogen atoms present in water. Under normal conditions, hydrogen nuclei are randomly oriented in space, but under the influence of a strong external magnetic field, these nuclei will align parallel to the external magnetic field, much like a compass needle that is aligned along the magnetic field of the earth. A magnetic resonance (MR) scanner contains such a strong external magnetic field. In the MR scanner, hydrogen nuclei are briefly exposed to a radio frequency pulse, exciting them to a high-energy state orthogonal to the external magnetic field. Following excitation, the nuclei will gradually “relax” toward their resting state along the external magnetic field, omitting the obtained energy as an MR signal. Measurement of these MR signals improves at a higher magnetic field strength, which is expressed in units of Tesla (T).

The speed of relaxation of hydrogen nuclei, and thus the intensity of the MR signal, depends on environmental factors. One of these factors is tissue type. Depending on the type of surrounding tissue, the speed of relaxation may differ in the order of tenths to several seconds. The differences in local MR signal strength, measured at a certain time point following excitation (termed “echo time”), allow for differentiation between, for example, bone, gray matter, white matter, and cerebral spinal fluid. Another environmental factor affecting the magnetic properties of hydrogen nuclei is the protein hemoglobin. Hemoglobin is responsible for oxygen transportation in blood and contains an iron molecule with different magnetic properties depending on whether oxygen is bound to hemoglobin or not. A change in the magnetic properties of this iron molecule affects the relaxation of the surrounding hydrogen nuclei. FMRI makes use of this principle, which enables the measurement of changes in the blood oxygen level-dependent (BOLD) signal in response to neuronal activity. This BOLD signal follows a slow (~15–20 s) hemodynamic response function (HRF) that is very similar across different brain regions. Therefore, we can measure the fMRI–BOLD response across the brain and consider this signal as an indirect measure of brain activity.

3.3 Spatial and Temporal Resolution of fMRI

FMRI provides images of the brain depicting BOLD signal intensity values. Each image consists of three-dimensional volumetric elements called voxels (Fig. 11.2). The dimensions of these voxels determine the spatial resolution. The maximum spatial resolution for measuring BOLD responses on 1.5- and 3-T scanners is approximately 3.5 mm, and 2 mm for 7-T scanners (Engel, Glover, & Wandell, 1997; Parkes et al., 2005; Shmuel et al., 2007). Whereas the spatial resolution determines anatomical details, the temporal resolution determines the precision in which we can investigate successive neuronal events. Up until recently, the full brain was typically scanned every 2–3 s. The temporal resolution heavily relies on the scanning protocol and, in recent years, cleverly

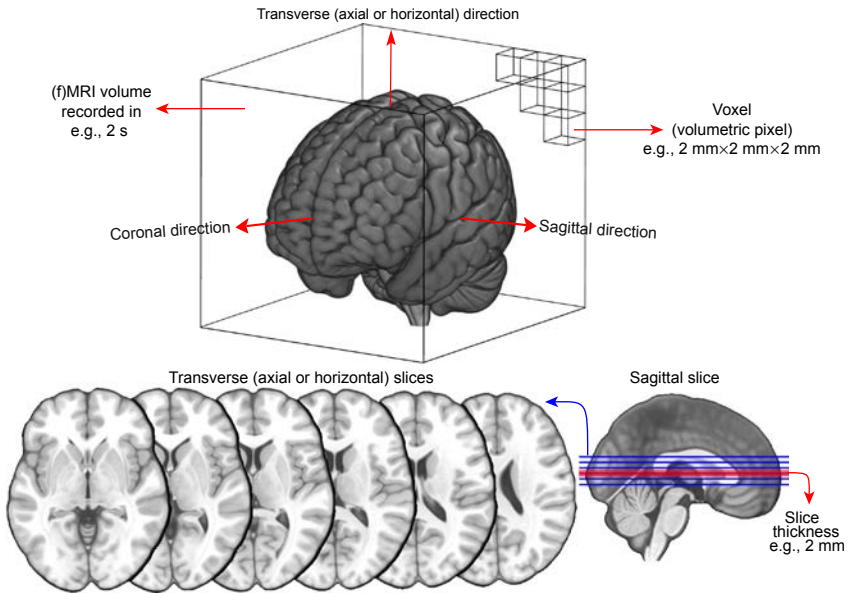


FIGURE 11.2 (F)MRI data representation. (F)MR images are three-dimensional volumes that consist of three-dimensional volumetric elements called voxels. Each volume contains a measurement of the full brain. To create a volume of data, data are acquired per slice or for multiple slices at the same time (termed multiband). The scanning is in one of three directions: transverse (also termed axial or horizontal, i.e., up–down or vice versa), sagittal (i.e., from right to left or vice versa), or coronal (i.e., from front to back or vice versa). Researchers commonly present their study results depicted on one or several slices. Sometimes the results are presented in a three-dimensional glass/see-through brain (not shown here).

constructed techniques were able to push toward a temporal resolution of up to 100 ms (Feinberg & Setsompop, 2013). However, faster scanning protocols may be more susceptible to signal artifacts and require special caution to avoid signal changes induced by, for example, vascular factors not related to BOLD effects (Duyn et al., 1994; Logothetis, 2008).

3.4 How Are fMRI Experiments Set Up?

3.4.1 How Many Participants Are Needed?

Most fMRI studies are set up as repeated-measures experiments with many stimulus repetitions. The use of within-subject designs reduces error variance as it allows removing effects of individual differences, which greatly increases statistical power. Several studies suggest that the minimum sample size of 16–20 participants is necessary for an optimum between costs and benefits in studies using a within-subject design (Friston, 2012; Mumford & Nichols, 2008; Pajula & Tohka, 2016).

In recent years, it became more important to investigate subtle perceptual differences between product alternatives resulting in research questions such as which

breakfast drink are consumers most likely to choose? or, what product properties differentiate vanilla-flavored yogurts? These questions concern subtle differences in brain responses between experimental conditions, and therefore require larger sample sizes to yield sufficient statistical power. Moreover, it is important to note that stimuli with little physiological significance will also induce small hemodynamic signal changes in the brain. A pleasant food stimulus, for example, might elicit a smaller physiological effect if a person is not hungry compared to the effect induced in the same person who is very hungry. If a researcher is interested in such subtle experimental effects a sample size of 16–20 might be insufficient.

3.4.2 *Positioning of the Participant and Stimulus Delivery*

fMRI experiments generally last for 1–2 h. During scanning the participant is lying in a supine position on a bed inside the bore of an MR scanner with his or her head placed in a head coil. In a task-based fMRI experiment, the participant engages in a computerized task paradigm. For experiments with visual stimulation, a computer screen displaying the stimuli is made visible for the participant via a mirror that is secured on the head coil. To interact with the computerized paradigm, hand-held MR-compatible button boxes or joysticks are commercially available. MR-compatible headphones can be used for the presentation of auditory stimuli. However, the loud noise of the MRI scanner limits studying auditory information processing.

Both the supine position and the strong magnetic field pose challenges for fMRI research that involves olfactory and/or gustatory stimulation. For gustatory stimulation, the type of food stimuli used in neuroimaging research is mostly limited to liquids because solid foods require chewing and swallowing, and these movements negatively affect the quality of BOLD (but also EEG) signals.

Stimuli are generally delivered using MR-compatible olfactometers (Sommer et al., 2012) and gustometers that are operated either by a computer or manually by the experimenter (Dalenberg et al., 2015; Veldhuizen et al., 2007). Olfactometers generally consist of machines that continuously blow air through tubes that end in the nostrils, and they offer the possibility of manipulating the aromas in the airstream with millisecond precision. Gustometers generally consist of several syringes containing different taste stimuli. The syringes are attached to tubes that end in a central mouthpiece, which is secured to the head coil and rests above the teeth of the participant, such that the participant is able to close his or her lips around the it.

3.4.3 *Experimental Design*

Because the fMRI–BOLD response is not an absolute measure of neuronal activity, fMRI designs require the option to statistically contrast neuronal activity of interest with an appropriate control condition. To investigate differences between these conditions or between experimental groups, researchers use the subtraction method. This method involves presenting participants with a stimulus and a similar stimulus that contains a small change. Subsequently, the brain response associated with one stimulus condition is subtracted from the brain

response associated with the other condition. The idea behind this method is that brain processes that are common in both stimulus conditions will cancel out while brain responses that differentiate between the two conditions are preserved. For example, taste stimuli that are delivered orally induce not only taste sensations but also tactile sensations and motor responses such as tongue and mouth movements. To remove such confounding effects, participants are generally presented with taste and neutral (tasteless) stimuli. Subtracting brain responses associated with the neutral stimulus from brain responses associated with the taste stimulus will cancel out any effects that are common in both conditions (e.g., tactile information). Resulting images from the subtraction method contain the effects of interest and are often referred to as contrasts.

In fMRI designs, stimuli are presented in so-called block designs, event-related designs, or a mixture of both. In a block design, stimuli that belong to one condition are grouped together (e.g., a stream of images belonging to the same food category). In event-related designs, different stimuli or conditions are intermixed. Event-related designs are especially useful to investigate (changes in) the shape of the HRF and the timing of different brain responses. In fMRI research, block designs have in general more power than event-related designs and are therefore more accurate in localizing mental processes associated with small stimulus differences.

3.5 How Are fMRI Data Analyzed?

When (f)MRI is covered in movies or TV programs, it often seems that the MR scanner immediately offers interpretable images. In practice this is rarely the case. Setting up an analysis, executing this analysis, and interpreting the results may take several months. In addition, it is important to note that the colorful “blobs” superimposed on brain images after finalizing data analysis do not depict activity in these areas but rather reflect areas where task-related activity fits a statistical model well enough to pass a certain statistical threshold.

There are multiple software packages to analyze fMRI data [e.g., SPM (<http://www.fil.ion.ucl.ac.uk/spm/doc/>), FSL (Smith et al., 2004), AFNI (Cox & Hyde, 1997), and BrainVoyager (Goebel, Esposito, & Formisano, 2006)], each with its own strengths and weaknesses. Nevertheless, all of these software packages contain a number of similar steps to analyze fMRI data, albeit the order of these analysis steps may differ per software package. Here, we will discuss three of these steps: preprocessing of data, first-level analysis (i.e., analysis on a single subject level), and second-level analysis (i.e., analysis on a group level).

3.5.1 Preprocessing

fMRI provides four-dimensional data: three dimensions in space (x , y , and z coordinates) and the fourth dimension constitutes time. Preprocessing fMRI data includes various steps to reduce variability in the data unrelated to the experimental task and to prepare data for subsequent statistical analysis. Here, we will cover the two most important steps.

First, during fMRI measurement, participants may move inside the bore of the MR scanner leading to small changes in the alignment of the head. These movements are especially unavoidable in studies that involve orally delivered stimuli as they require tongue movements and swallowing. A displacement of the head between two fMRI images, as small as 2 mm, may already mean that the same brain tissue is represented in a different voxel after movement. To ensure that every voxel represents the same underlying tissue in all magnetic resonance images, the data are corrected for head movements, a process called realignment.

A second important preprocessing step concerns the individual differences in brain size and shape. To deal with this problem, the neuroimaging community uses a standardized brain template including a coordinate system provided by the Montreal Neurological Institute (MNI). During the normalization step, an anatomical image of each individual brain is transformed in three-dimensional space to this MNI template. This step requires complex mathematical computations and the aforementioned software packages offer several solutions to this problem.

3.5.2 *First-Level Analysis*

During first-level analysis, linear regression is applied to analyze fMRI data per participant using a so-called mass univariate analysis, that is, performing a univariate analysis on up to 200,000 voxels (depending on voxel size). To understand a first-level analysis, imagine the following study investigating whether pictures of apples and oranges are differently represented in the brain. The study includes 20 participants that enter the MR scanner and they are instructed to look at streams of pictures containing different apples and oranges. A simple two-condition, block design is used: the different blocks consist of 10 images of either an apple or an orange presented for 10 s each. To examine whether the BOLD responses are dependent on picture type, a regression model is fitted to the time course of every single voxel. The time course refers to the response signal, that is, the BOLD signal, measured in a single voxel over time, which constitutes the dependent variable in the linear regression model. The apple and orange conditions constitute the independent (dummy) variables, taking the values of 0, indicating the absence of a specific picture, and 1, indicating the presence of that picture (Fig. 11.3a). The model assumes that the BOLD signal responds to neuronal activity following a specific HRF (Fig. 11.3b). This means that the onset of a stimulus (e.g., a picture of an apple) is associated with approximately 20 s of BOLD signal post stimulus onset. To take the delay and shape of the BOLD signal into account, the presentation of an apple is “convolved” with the HRF (Fig. 11.3c). Thus, the convolved signal is a prediction of the BOLD signal associated with a stimulus. The regression analysis estimates how well this predicted BOLD signal fits the measured BOLD signal in each voxel.

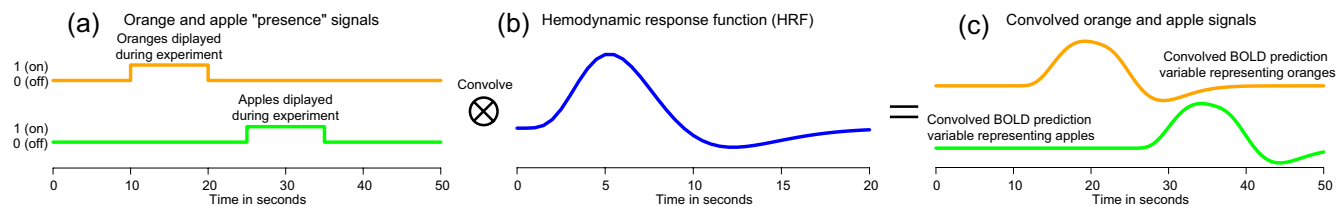


FIGURE 11.3 Convolution of the independent variables with the hemodynamic response function (HRF). (a) The course of the independent variables, taking the values 0, indicating the absence of a specific picture, and 1, indicating the presence of that picture. (b) The HRF of the anticipated blood oxygen level-dependent (BOLD) response. (c) The convolved signal representing the predicted BOLD signal. Regression analysis is applied to examine how well this predicted signal fits the observed BOLD signals in the brain.

Fitting a multiple regression model to the current data example will result in three beta-estimates per voxel: one beta-estimate for the intercept and two beta-estimates for the fruit conditions. The intercept represents the average signal when not watching fruit images (i.e., the baseline). The baseline often represents a control condition such as watching a fixation cross. These beta-estimates for the fruit conditions indicate how strong the HRF was represented in a voxel for watching either apples or oranges compared to the intercept. The beta-estimates are obtained for each voxel and thus allow constructing new brain maps: one map containing beta-estimates for watching apples and one map containing beta-estimates for watching oranges. Repeating the first-level analysis for every subject will result in 20 beta maps representing how strong each voxel is associated with watching apples and 20 beta maps representing how strong each voxel is associated with watching oranges. These statistical maps are used for second-level (i.e., group-level) analysis.

3.5.3 *Second-Level Analysis*

Recall that fMRI data are already normalized to MNI space to ensure interpersonal alignment. Therefore, the experimenter can use the obtained beta maps for every participant to calculate statistics on a group level. The data can be analyzed using either the univariate approach (termed the “classical” approach) or a multivariate approach, often referred to as multivariate patterns analysis (MVPA).

3.5.3.1 The Univariate Approach

The classical univariate fMRI analysis is typically employed to identify voxels (i.e., brain regions) associated with a particular task or voxels that differentiate between experimental conditions or groups. In the current example the experimenter is interested in how watching apples and oranges is differently represented in the brain. To find this difference the experimenter can use the beta maps of each participant to perform a paired-sample T-test. This T-test is performed per voxel and can be used to construct a group-wise contrast between the two conditions. This contrast will indicate which voxels showed higher BOLD responses for watching apples versus watching oranges, or vice versa. This statistical test is performed on a very large number of voxels, increasing the chance that the null hypothesis is falsely rejected (Type I error) and thus creating a multiple comparison problem. There are several ways to deal with this problem: (1) ignoring the problem, (2) applying a family-wise error (FWE) correction on a whole-brain level, or (3) applying an FWE correction using small-volume correction (SVC).

Obviously, not correcting for multiple comparisons is not recommended but it may be possible that the effects on group level are so subtle that any kind of multiple comparison correction would mask the result. Although a commonly used uncorrected threshold is $P=.001$, such results should be interpreted with caution

as one has a stronger argument for claiming that the results are not generalizable. It is therefore highly recommended to correct for multiple comparisons.

In other disciplines the Bonferroni correction is a common method for FWE correction. For fMRI data, however, the Bonferroni correction has two major disadvantages: the method is very strict and will largely increase the number of false negatives (Type II error) and, more importantly, the Bonferroni correction assumes that the statistical tests are independent while the statistical tests performed on fMRI data are not; BOLD signals in neighboring voxels are highly correlated. As of this writing, the two most used corrections that circumvent these problems with a Bonferroni correction are (1) the FWE correction using random field theory to estimate the number of independent tests and (2) the false discovery rate, which controls the expected proportion of rejected hypotheses that are false positives (Nichols & Hayasaka, 2003). These corrections are performed on a whole-brain level. However, sometimes it is illogical to be overly strict if the experimenter has a strong hypothesis about where he or she will expect to find results. Suppose that the experimenter from the example study already performed multiple fruit studies beforehand and is absolutely sure that he will find the results in a brain area that he termed the dorsomedial fruit cortex. With such a strong hypothesis, it makes no sense to also include the rest of the brain and become overly strict in the FWE correction. Therefore, the experimenter can apply an SVC to reduce the (estimated) number of separate statistical tests to the voxels that comprise the dorsomedial fruit cortex.

3.5.3.2 Multivariate Patterns Analysis

The univariate analysis approach is limited to the analysis of isolated voxels and makes no use of information from neighboring (or other) voxels but their responses may very much be related. To use information represented across multiple voxels, multivariate approaches have gained increasing attention in recent years. Most multivariate approaches involve the application of pattern-classification algorithms that allow investigating how mental representations are associated with (local) patterns of BOLD responses (e.g., Norman et al., 2006). Chikazoe et al. (2014), for example, studied participants engaged in separate tasks in which they were presented with complex visual stimuli and basic tastes. After each stimulus presentation, participants were asked to rate the perceived pleasantness of the stimulus. Using MVPA, the authors found that specific localized patterns of activity in the orbitofrontal cortex (an area associated with affective judgments) were related to affective coding of both visual and gustatory stimuli. In a study of our own, we investigated how subjective evaluation was represented in the brain by studying the difference between likers and dislikers of grapefruit juice using MVPA on global patterns localized across the whole brain (van den Bosch et al., 2014). We found a global pattern of brain areas that, apart from the orbitofrontal cortex, discriminated likers from dislikers of grapefruit juice.

These studies illustrate that brain areas do not operate in isolation but function based on incoming information and propagating information to other areas. Developments in fMRI research focus on additional methods to investigate how areas communicate with one another. These methods examine connectivity by investigating the correlation between areas or by investigating whether correlation between areas changes based on an experimental condition [e.g., by using psychophysiological interaction or PPI analysis (McLaren et al., 2012)].

4. ELECTROENCEPHALOGRAPHY

Whereas fMRI is an imaging technique that provides excellent spatial resolution, EEG is a high-temporal-resolution technique, especially suitable for studying the temporal dynamics of brain activity associated with the processing of information. In addition, EEG is a direct measure of neuronal activity. There are many excellent resources available on the neurophysiological underpinnings and principles of the EEG technique (Buzsáki, Anastassiou, & Koch, 2012; Cohen, 2014; Kappenman & Luck, 2012; Luck, 2014; Nunez & Srinivasan, 2006; Wang, 2010). Here we present an overview of the most important terms and concepts and offer references for further reading. We will start with pinpointing what types of questions can be addressed using EEG. Subsequently, we will explain the basic sources of information present in the EEG signal, how EEG experiments are generally set up, and also how the continuously recorded signal is analyzed.

4.1 What Questions Can We Answer Using EEG?

EEG provides a continuous measure of neuronal activity that can be recorded from multiple scalp locations with a high temporal resolution in the order of 1 ms. Both bottom-up and top-down processes involved in the perception and interpretation of information and the subsequent selection and execution of appropriate behavioral responses occur within tens to hundreds of milliseconds. Owing to the high temporal resolution, EEG provides the ultimate tool to answer questions regarding the temporal dynamics and sequential ordering of these processes. EEG is, for example, especially suited to discriminate early perceptual processing of sensory stimuli; it has indeed successfully been used to study how quickly an individual is able to discriminate between different tastes (e.g., sweet and salty) (Hashida et al., 2005; see for review: Ohla, Busch, & Lundström, 2012).

In general, EEG is applied to study brain activation time-locked to specific events or stimuli. So far, EEG studies have mainly examined the neurobiology of taste processing using visual representations of food, because accurate timing of orosensory stimulation forms a challenge in EEG research (Hoogeveen et al., 2016; Nijs, Franken, & Muris, 2008, 2009; Toepel et al., 2009). Just like fMRI studies performed in the sensory science context, these EEG studies are primarily focused on understanding differences between consumer behavior in different populations (e.g., lean and obese individuals). The few EEG studies

that were done to specifically study processing of food cues were mainly performed in healthy participants (e.g., [Asmaro & Liotti, 2014](#)).

EEG can also be used to examine how different networks of interacting brain regions support behavior. Since the late 1980s, the interest in applying EEG to study functional connectivity has increased noticeably (see for reviews: [Hassan et al., 2014](#); [Lang et al., 2012](#)). A variety of linear and nonlinear methods are available to perform these analyses ([Cohen, 2014](#)). The connectivity measures are based on EEG power. EEG power refers to how strongly a specific frequency is represented in the EEG signal. These measures are comparable to connectivity measures obtained using PPI analysis in fMRI studies. The power-based EEG measures reflect relatively slow modulations of the correlations observed between different brain areas ([Cohen, 2014](#)).

4.2 How Does EEG Work?

Neurons receive information from other neurons through their dendrites and transmit outgoing signals to neighboring neurons through their axon. The electrical signal that is transmitted from the dendrites via the cell body to the axon can be classified into two basic types: graded “postsynaptic” potentials occurring in the dendrites (and cell body) and the action potential, which is fired through the axon. The voltage fluctuations that are recorded at the scalp using EEG mainly originate from the postsynaptic potentials.

Electrical fields generated by a single neuron are too weak to be measured outside the head. However, when neurons in a large population (thousands or millions) are synchronously active, their electrical fields sum and become strong enough to be measured by electrodes placed on the outside of the scalp. Hence the EEG signal is a direct manifestation of coherent simultaneous postsynaptic activity of a large number of neurons. In addition, the frequency oscillations observed in the EEG signal are direct measurements of oscillatory activity in these neuronal populations. It should be noted that the EEG signal recorded using scalp electrodes mainly reflects cortical activity. This is related to volume conduction properties of the brain and the spatial alignment of neurons located deeper inside the brain. In contrast to EEG measured at the scalp, single-unit recordings (i.e., in vivo recordings of individual neurons using electrodes that are placed close to the neuron) measure action potentials instead of postsynaptic potentials.

4.2.1 Event-Related Potential

In clinical settings, the EEG technique is mainly used to record spontaneous electrical activity over a period of time from sleeping or awake individuals. Interpretation of the signal for diagnostic purposes is focused on the detection of abnormalities in the spectral components of this signal. However, a common approach used to gain insight into neuronal processes underlying (consumer) behavior is focused on how brain activity is modulated by a particular stimulus or event. The neuronal response evoked by a stimulus or event is represented in the so-called “event-related potential” (ERP). The ERP is a tiny signal embedded in the ongoing EEG. Averaging

the EEG signal across multiple trials of the same (category of a) stimulus or event reduces background noise that is unrelated to the event of interest, leaving the ERP (Luck, 2014). A significant feature of the ERP is that this potential provides a precise temporal representation of underlying neuronal processes. Note that ERPs can be measured in response to stimuli that do not require an overt response, which therefore cannot be studied using more traditional behavioral measures.

The ERP consists of a sequence of different positive and negative deflections reflecting underlying components (Fig. 11.4). These components are typically related to specific functional processes such as attention, memory, or decision-making. For this reason, investigating ERPs in the ongoing EEG signal is especially suited to addressing questions about the timing and sequence of neuronal processes, whereas fMRI–BOLD responses elucidate the spatial representation of neuronal processes. An ERP is generally graphed with microvolts on the y axis and time on the x axis. If an ERP represents a time-locked average of a repeated event of interest, the origin of the graph (i.e., where the x and y axes meet) is usually depicted as time 0, representing the onset of the event to which the data are time-locked. ERP graphs show about 100–200 ms of activity prestimulus, also referred to as the baseline period. The positive and negative voltage deflections or peaks in the ERP data are labeled to indicate whether they are positive (P) or negative (N) in direction and in what order they emerge in the graph (e.g., P_1 , N_2 , P_3 , etc.) or at what time they occur in the order of milliseconds (e.g., P_{300}). In addition, ERP researchers often show the topography of the ERP data on a spatial map depicting the spatial distribution of the observed neuronal signal across the scalp.

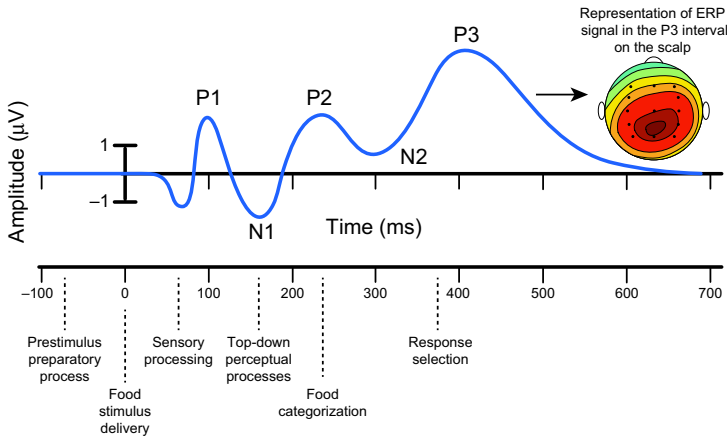


FIGURE 11.4 Example of an average stimulus-locked event-related potential (ERP). ERP components are denoted. A timeline of different cognitive operations that might be involved in taste perception is indicated below the x axis. The graph shows 100 ms of prestimulus activity, also referred to as the baseline period. In addition, the topography (i.e., spatial distribution) of the P3 component is shown on a spatial map (looking down at the top of the head; black dots represent different electrode locations). The scalp location on which the largest amplitude is measured is indicated in dark red.

ERP researchers are typically interested in comparing the size (i.e., amplitude) of ERP components elicited in response to a condition of interest and a control condition, or comparing different levels of the variable of interest (e.g., different intensity levels of sweetness). In the fMRI section, we referred to this as contrasts. For example, a specific ERP component, called the late positive potential, was found to increase in amplitude after presentations of highly appetitive pictures relative to neutral control stimuli (Gable & Harmon-Jones, 2010). Furthermore, contrasts of ERP amplitudes have been compared across (clinical) populations to disentangle neuronal mechanisms underlying differences in behavior. For example, Nijs et al. (2009) showed that the amplitude of the P₃₀₀ component, observed at parietooccipital electrodes, was larger in response to food-related pictures in individuals having difficulty resisting food compared to individuals who had no problems ignoring food stimuli.

4.2.2 Event-Related Spectral Perturbations

ERPs represent only a limited amount of the information that is present in the EEG signal. Therefore, the interest of researchers has broadened from ERPs to the time–frequency approach to study the relation between behavior and neuronal oscillations in the human brain. Oscillatory changes that are related to the presentation of a stimulus or the performance of a certain task are called event-related spectral perturbations (ERSPs), which can be described using three defining characteristics: frequency, power, and phase. First, the frequency of oscillations is the number of oscillations per unit of time, usually expressed in the number of oscillations per second (hertz or Hz). EEG research relevant to the understanding of neuronal processes mostly focuses on oscillations between 1 and 80 Hz. Five frequency bands are discerned: delta (1–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), beta (13–30 Hz), and gamma (30–80 Hz). Second, power refers to the amount of energy in specific frequency bands. Third, the phase of oscillations is the point in the oscillation at a specific moment in time.

Changes in oscillatory activity in specific frequency bands have been related to different neurobiological mechanisms. For example, emotional valence of affective stimuli, such as faces, music, insects, and erotic pictures, was associated with the power in the alpha band of the frontal cortex (Allen & Kline, 2004; Chang et al., 2015; Kang et al., 2015; Schöne et al., 2016). An in-depth introduction to the measurement and analysis of brain oscillations as measured with EEG and their importance for understanding neuronal processes can be found in Cohen (2014).

4.3 Spatial and Temporal Resolution of the EEG

Most EEG research focuses on the timing of neuronal events, as the temporal resolution is in the order of milliseconds. However, different source localization techniques are available to model and estimate the spatiotemporal origin of neuronal currents that generate the EEG signal (Jatoui et al., 2014). The spatial resolution of EEG depends on the number of electrodes used. Available EEG caps might contain up to 256 electrodes, although 32 or 64 electrodes are more common. Given

the topographical distribution of the EEG signal, source localization techniques compute the possible distribution of currents within the brain that generated these signals. However, these methods face one major problem: there is no unique set of sources that can explain the voltage distribution measured at the scalp (termed “the inverse problem”). A complicating factor is that EEG measures are less sensitive to brain activity originating from deep brain structures. Although approaches have been developed to limit the number of possible solutions, EEG remains less optimal than fMRI to investigate the spatial origin of neuronal signals.

4.4 How Are EEG Experiments Set Up?¹

4.4.1 How Many Trials Are Needed?

The signal measured using EEG consists of brain activity elicited by specific stimuli or events and activity not related to these stimuli or events (i.e., noise). Noise is assumed to vary randomly over trials, whereas event-related activity is time-locked to the stimuli or events. For ERP analysis, it is important to include a sufficient number of trials, as averaging more trials will decrease the contribution of noise to the measured signal. The signal-to-noise ratio increases as a function of the square root of the number of trials. As a rule of the thumb the following numbers are suggested by Luck (2014): approximately 30–40 trials per condition/participant to identify large ERP components, 150–200 trials per condition/participant for medium-sized components, and 300–500 trials to identify small components. However, note that it is usually easier to improve the quality of data by decreasing sources of noise than by increasing the number of trials, especially because more trials generally result in longer experimental sessions, possibly introducing additional confounders (e.g., fatigue, boredom).

4.4.2 Positioning of the Participants and Stimulus Delivery

The EEG signal can be recorded while the participant is asleep or awake, during rest, or while he or she is engaged in performing a task. During task performance, participants are generally seated in an upright position in a comfortable chair. Major sources of electrical noise should be avoided in the vicinity of the recording system. A set of electrodes, usually embedded in an elastic cap, is placed on the participant’s head. A gel is used to improve electrical conduction between each electrode and the scalp beneath it. The appropriate number of electrodes is dependent on the experimental design and planned analysis. The electrodes are generally placed according to the international 10–20 system or an extension of this internationally recognized method to describe and apply the location of scalp electrodes (American Electroencephalographic Society, 1994; Jurcak, Tsuzuki, & Dan, 2007). Each electrode can be identified by a name starting with one or two letters to identify over which lobe (e.g., F for frontal lobe) the electrode is

1. The sample size in EEG studies depends on the size of the effect you are interested in, comparable to fMRI studies (see Section 3.4.1).

positioned and a number or letter to identify hemispheric locations. For an experienced researcher, it takes about 30 min to complete the application of a cap containing 64 electrodes. EEG records electrical potentials over the scalp relative to the voltage at a reference electrode. Reference electrodes are frequently placed over the mastoid bones directly behind the ears or at the earlobes (Luck, 2014).

To take advantage of the temporal resolution of the EEG technique, an accurate timing of stimuli or events is an essential prerequisite during recording of the signal. Stimulus delivery via a computer, using specific software, ensures this accurate timing of the presentation of stimuli and recording of responses. To reduce timing errors in response times, the EEG equipment can be easily extended by recording the electromyogram or using eye tracking.

4.4.3 Experimental Design

The time dimension accessible to EEG offers considerable variety in the design of experimental paradigms for testing fundamental and applied questions in sensory science. The most common experimental design in EEG studies examining information processing is the event-related design, enabling investigation of multiple conditions (e.g., pictures, sounds, words, etc.) presented in a randomly interleaved order. The event-related design can be used to investigate stimulus-locked and response-locked ERPs. For a stimulus-locked ERP analysis, the onset of a stimulus constitutes the onset of the event, while for a response-locked ERP, the behavioral response constitutes the onset time of the event. Note that the event-related design can also be applied if the event or stimulus of interest can be defined only after task performance. For example, brain activity in trials in which an incorrect response was provided can be compared to that in trials in which correct responses were given, or pictures that were rated during the experiment by the participant as positive can be compared to negative pictures.

A large number of experimental paradigms that stem from a long tradition of research in cognitive psychology are available to target specific neuronal processes (Eysenck & Keane, 2010; Parkin, 2013). For example, the priming paradigm, in which a brief exposure to a (subliminal) stimulus (i.e., prime) is followed by a new stimulus, is an appropriate paradigm to assess food attitudes related to implicit memory. Lamote et al. (2004), for example, showed that individuals were faster in categorizing neutral words if these words were preceded by images of liked food compared to priming with images of disliked food. Hoozevee et al. (2016) also showed that sensory associations of food (e.g., taste quality) are more strongly represented in memory compared to nonsensory associations of food (e.g., health) using a priming paradigm.

4.5 How Are EEG Data Analyzed?

The continuous EEG signal is amplified, digitized, and stored as a set of discrete voltage measurements on a computer. The minimum acceptable sampling rate used to digitize the signal is approximately two to three times greater than the

highest frequency you are interested in. In general, a sampling rate between 250 and 1000 Hz is recommended for most experiments aiming at understanding information processing in consumer science.

We will here provide an overview of the main steps in the analysis of the EEG signal, focusing on the ERPs. For the analysis of ERSPs we refer the reader to [Cohen \(2014\)](#). Note that the EEG data analysis pipeline might differ, depending on specific research questions and paradigms used. Similar to the fMRI section of this chapter, we will discuss three steps: preprocessing of data, first-level analysis (i.e., analysis on a single subject level), and second-level analysis (i.e., analysis on a group level). As for fMRI analysis, there are several software packages available for analyzing EEG data [e.g., EEGLAB toolbox ([Delorme & Makeig, 2004](#)), BrainVision Analyzer (Brain Products GmbH), and FieldTrip ([Oostenveld et al., 2011](#))].

4.5.1 Preprocessing

While signal averaging will increase the signal-to-noise ratio, it is not sufficient to deal with all artifacts present in the EEG signal. To deal with these artifacts, any reliable analysis must be preceded by a preprocessing stage. There are several types of noise or artifacts that can contaminate EEG recordings, including ocular artifacts, neuromuscular activity, and noise from external sources, such as mains noise (i.e., signal interference associated with the alternating current of the power supply).

A process termed (linear) filtering is applied to the EEG signal to eliminate noise frequencies that are not overlapping with signal frequencies originating from the brain you are interested in. EEG researchers typically use linear filters that attenuate specific ranges of frequencies. The most common types of these filters are: (1) low-pass filters, which attenuate high frequencies and pass low frequencies; (2) high-pass filters, which attenuate low frequencies and pass high frequencies; and (3) bandpass filters, which attenuate both high and low frequencies. It is important to realize that filters can significantly distort ERP waveforms, changing the amplitude and timing of ERP components. One should therefore be careful in selecting which filter to apply to the data. A more detailed explanation on this topic can be found in [Luck \(2014\)](#).

In addition to linear filtering, there are two other main classes of techniques to eliminate artifacts: signal rejection and signal correction. Eyeblinks and eye movements, for example, can be detected by measuring the electrical signal recorded from electrodes placed close to the eye [i.e., the electrooculogram (EOG)]. Subsequently, trials in which the EOG voltage exceeds a threshold level can be excluded from further analysis. Alternatively, correction algorithms are available that remove eye movement artifacts from the EEG signal (e.g., [Gratton, Coles, & Donchin, 1983](#)). A more recent, but also more complex, approach to identify and correct for artifacts is based on independent component analysis ([Mennes et al., 2010](#)).

4.5.2 First-Level Analysis

The next steps in EEG analysis involve epoching (or segmenting) the data into separate trials and applying baseline corrections to these trials. Usually, baseline correction involves subtracting the average amplitude of the signal in the 100- or 200-ms interval before the onset of the event from the overall signal to correct for differences in signal offsets. Furthermore, epochs belonging to the same category of event of interest are averaged. These steps are not commonly referred to as first-level analysis in EEG research. However, as these processing steps take into account stimulus and response times, we here categorize these steps under first-level analyses to be consistent with the earlier fMRI section.

Subsequently, researchers usually concentrate on the amplitude and/or latency of one or more ERP components observed within specific time intervals in the average ERP. There are two common ways to measure the amplitude of ERP components. The first method is to define a time window for each waveform being measured, and find the maximum amplitude and related latency in that time window (peak amplitude/latency). An alternative method is to define a time window and calculate the mean voltage in that time window (mean amplitude) or measure the sum of the voltages at each time point within the measurement window (area under the curve).

4.5.3 Second-Level Analysis

Once ERP amplitudes and latencies are collected from a sample of subjects, it is time to perform statistical analyses to see whether the hypothesized effects reach the level of significance. Various statistical packages are available to perform these analyses.

5. EXAMPLE STUDIES

The number of fMRI and EEG studies is expanding rapidly. As these neuroimaging techniques receive increasing attention, the analysis methodology used also becomes increasingly sophisticated. In this chapter we tried to cover the basics that are needed to understand and assess the majority of the studies. Unfortunately, not all neuroimaging articles lead the reader by the hand by explaining how a study was performed. Two fMRI studies that used methodology explained in this chapter and also give detailed graphical insights into the study setup, paradigm used, measured BOLD/HRF responses, statistical tests, and stimulus delivery were performed by [Bender et al. \(2009\)](#) and [Veldhuizen et al. \(2007\)](#).

We refer the reader to [Gable and Harmon-Jones \(2010\)](#) and [Nijs et al. \(2008\)](#) for insightful EEG studies in the current field. These studies provide good examples of how the methods explained in this chapter can be applied and also provide insights into the measured signals and how to interpret them.

6. FINAL REMARKS

A broad diversity of techniques is available to study consumer behavior. The neuroimaging techniques discussed in this chapter provide noninvasive methods to examine brain processes underlying this behavior. Therefore, these techniques might form a valuable contribution to the more traditional behavioral and subjective measures applied to understand the relation between brain processes, behavior, and health. As a researcher you have to choose the method that best fits the question you want to answer. In the preceding we hope to have provided information that might help you make the right choice (see [Table 11.1](#) for an overview).

For every researcher it is important to guard the quality of the experimental results. As research using neuroimaging techniques is rather complex, many researchers in this community have started initiatives to improve the quality of imaging research as a whole. As a result, there are multiple data repositories that allow for replication studies and for metaanalyses, but also for testing new hypotheses and analyses. Furthermore, various organizations (e.g., the Organization for Human Brain Mapping) have created guidelines and recommendations to increase the reproducibility and quality of neuroimaging experiments. In addition, various platforms are available to pose your questions and share solutions.

TABLE 11.1 Comparison Between Functional Magnetic Resonance Imaging And Electroencephalography	
Functional Magnetic Resonance Imaging	Electroencephalography
Not invasive, participants can be scanned many times	Not invasive, participants can be measured many times
Indirect measure of brain activity	Direct measure of brain activity
Expensive data acquisition and limited availability	“Cheap” data acquisition and widely available
Not portable/static setup	Portable setup
High spatial resolution (1–4 mm)	Low spatial resolution (1–10 cm depending on the number of electrodes used and limited to cortical surface areas)
Low temporal resolution (1–10 s)	High temporal resolution (≤ 1 –2 ms) (study of surface brain structures)
Sensitive to activity in deep brain structures	Less sensitive to activity generated in deep brain structures
Magnetic activity (blood oxygen level-dependent response)	Electric activity (event-related potential, event-related spectral perturbation)

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Chapter 12

Eye Tracking in Consumer Research

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1. INTRODUCTION

Human perception systems can process information from their sensory fields simultaneously; however, narrow limits on how much we can do in parallel exist. Cognitive psychology has proposed that there are serial bottlenecks, points in human information processing, at which data can no longer be processed in parallel for every perception system (Anderson, 2015). Because visual perception results in an information flow that is much higher than that of other perception systems, very effective mechanisms to reduce the incoming data to a degree that can be processed by the brain exist. One of the

bottlenecks in visual information processing is a result of the physiology of the vision system. Although we can see quite a wide visual field, the area of the retina (fovea) in which the concentration of photoreceptor cells (cones) is much higher than in the rest of the retina can register only a small part of it. When we focus on a certain object, we use the fovea, the most powerful visual resource, to look at it. So, by choosing where to focus our gaze, we choose for which parts of the visual field we use the fovea and which parts get only limited resources. Usually, we align our eyes to the relevant aspect in our visual field in a way that it is depicted on the fovea and we attend to that part of the visual field, on which we are focusing. In a way visual attention can be seen as the gatekeeper for incoming visual information and, therefore, visual attention, as a very important step of visual information processing, is the focus of scientific investigation of visual information processing. Visual attention can be driven either by the stimuli themselves (bottom-up or exogenous factors) or by the individual's goals (top-down or endogenous factors) (Corbetta & Shulman, 2002). A famous demonstration of the effects of sustained goal-driven attention, which can result in change blindness, was reported by Simons, Chabris, Schnur, & Levin (2002).

The most successful observational technique to investigate visual behavior and visual attention is eye tracking, which is the process of identifying where and how someone is looking. Eye tracking has already been used in various scientific and research fields (Blake, 2013; Liversedge, Gilchrist, & Everling, 2011; Mele & Federici, 2012; Partala & Surakka, 2003; Rauthmann, Seubert, Sachse, & Furtner, 2012). Academic research uses it to gain insights into the principles of the human visual system (Carrasco, 2011; Holmqvist, 2011; Liversedge et al., 2011). Psychology in general is highly interested in eye tracking because it allows insights into the mechanisms of reading (Bonhage, Mueller, Friederici, & Fiebach, 2015; Lai et al., 2013; Mele & Federici, 2012; Steinfeld, 2016; Vitu, 2011), into disorders of social interaction like autism or schizophrenia (Benson & Fletcher-Watson, 2011; Chen, Levy, Sheremata, & Holzman, 2006; Falck-Ytter, 2015; Guillon, Hadjikhani, Baduel, & Rogé, 2014; Laurent Itti, 2015; Pierce et al., 2016; Wang et al., 2015), into sexual behavior (Dixon, Grimshaw, Linklater, & Dixon, 2009; Dixon, Grimshaw, Ormsby, & Dixon, 2014; Rieger & Savin-Williams, 2012; Rupp & Wallen, 2007; Yang, Chen, Hu, Zheng, & Wang, 2015), and also into emotions (Calvo & Lang, 2004; Ng & Hort, 2015). In the clinical field, eye tracking is used for diagnosis of functional deficits of visual disorders, but another interesting application of eye-tracking techniques is related to their use by disabled individuals (e.g., persons suffering from amyotrophic lateral sclerosis) to guide computer interfaces of robots merely by their gaze. Eye tracking is used in usability and experience tests of consumer goods, packaging, and software products (Bojko, 2013; Goldberg & Anna, 2002). Web, software, video, and media designers as well as media and advertisement consultants are using eye trackers to maximize the impact of advertisements and information (Almeida, Mealha, & Veloso, 2016;

Chandon, Hutchinson, Bradlow, & Young, 2009; Loyola et al., 2015; Maughan, Gutnikov, & Stevens, 2007; Navarro, Molina, Lacruz, & Ortega, 2015; Sharafi, Soh, & Guéhéneuc, 2015; Wang, Yang, Liu, Cao, & Ma, 2014; Wedel & Pieters, 2008b). There is also a wide field of applications in human factor research regarding cars, nuclear plants, sports, and product design (Guo, Ding, Liu, Liu, & Zhang, 2016).

In particular, eye tracking has generated a great amount of interest in sensory and consumer research, motivated by the need for methods that provide reliable and valid insights into consumers' expectations, perceptions, memories, emotions, and decision-making processes, to explain and predict their behavior (Bojko, 2013). It is well known that food choice is complex and determined by many interrelated factors, including intrinsic and extrinsic product characteristics, but also biological, physiological, psychological, situational, and sociocultural factors (Köster, 2003, 2009). However, it is frequently argued that "the first taste is almost always with the eye" (Imram, 1999), which indicates that the first visual contact with food products triggers expectations, memories, emotions, etc., and thereby also influences the subsequent product perceptions, like smell, taste, and flavor. Consequently, visual appearance is a vital component of total food quality perception and significantly influences food choice and food-related behavior in general (Hutchings, 2012; Jaros, Rohm, & Strobl, 2000; van der Laan, de Ridder, Viergever, & Smeets, 2011; van Meer, van der Laan, Adan, Viergever, & Smeets, 2015). Because the rapid development of information technology has given consumers the possibility of ordering and purchasing food using their mobile devices, the visual appearance of food items in pictures has also become of vital interest to food manufacturers using such media (Zhang & Seo, 2015).

There have been several historical attempts to characterize eye movements, e.g., by self-reports on gazing behavior. The detail level of self-reports is limited, because eye movements are some of the fastest movements of the human body and the gaze patterns formed are very complex (Liversedge et al., 2011). The most promising method to investigate eye movements, visual perception, and visual attention is to characterize gazing behavior with eye-tracking techniques. Eye tracking is an observational technique, because it observes an important aspect of human behavior, namely eye movements, which characterize the gazing behavior. The human gaze on still objects is not characterized by smooth movements over the observed object but rather jumps in the form of saccades, stopping at shorter or longer fixations. Eye-tracking devices are able to detect such saccades and fixations of the viewer's eyes and therefore can calculate several parameters characterizing gazing behavior. Although gaze can be controlled by will, in testing situations in which the tested individuals are not informed about the test goal and the fact that their gaze is being captured, eye tracking can be regarded as an implicit measurement capturing automatic, involuntary, and unconscious reactions, which are not biased by conscious cognitive thinking. In particular, unconscious thoughts, which are

goal dependent, play an important role in decision-making and also contribute to post-choice satisfaction (Bos, Dijksterhuis, & Baaren, 2008; Dijksterhuis, 2004; Dijksterhuis & Aarts, 2010; Dijksterhuis, Smith, van Baaren, & Wigboldus, 2005; Dijksterhuis & van Olden, 2006).

2. PRINCIPLES AND TECHNICAL SOLUTIONS TO CHARACTERIZING GAZING BEHAVIOR

2.1 Principles

Eye-tracking devices allow one to measure and analyze eye movements to characterize gaze behavior. Eye trackers can investigate only overt visual attention, which occurs when the observer's visual attention matches the fixated aspect of the stimulus. In contrast, covert visual attention occurs when the attention is not on the fixated aspect, but intentionally focused on a peripheral one within the field of vision. Overt visual attention is the default mode of everyday visual attention, also because covert visual attention needs a considerable amount of effort. William James proposed a differentiation between focused and dispersed attention (James, 1890), which are extremes in the spectrum of attentional states. This idea was used to develop the model of visual search in two stages by Shaw and Shaw (1977). The first stage comprises fast, parallel involuntary processes (dispersed attention) and the second, attentive part comprises slower, serial, voluntary processes (focused attention). This theory has been refined in the feature integration theory of visual selective attention by Treisman and Gelade (1980). Posner, Petersen, Fox, and Raichle (1988) showed that successful control of eye movements needs dispersed attention on places outside the fovea to be able to identify interesting nonfoveal regions we can fixate on next. In a way, this theory can be seen in analogy to Daniel Kahneman's theory of two cognitive strategies to make choices: fast, intuitive thinking and slow, rational thinking (Kahneman, 2011).

However, there also exist unconscious eye movements and fixations, which may potentially influence the gazer's behavior too. Merikle and Joordens (1997) suggest that "consciously perceived stimuli can guide intentional actions, whereas unconsciously perceived stimuli lead to more automatic or habitual reactions." Eye trackers register both conscious and unconscious eye movements of overt visual attention, but they are not able to register conscious or unconscious covert eye movements.

Today's major eye-movement measuring method is the pupil and corneal reflection method. Light gets through the pupils into the eye and to the retina, whereas the cornea, which covers the outside of the eye, reflects light. Corneal reflections of near-infrared (glint or Purkinje reflection) are the brightest reflections and invisible to the participant. Therefore near-infrared is used to measure the position of the pupils. The brighter the ambient light is, the smaller the pupil becomes, and the more precise the measurement is. An eye tracker working with infrared consists of cameras, projectors, and algorithms

to calculate the exact gazing location. The projectors create a pattern of near-infrared light on the eyes of the participant, which is partly reflected. The cameras take high-frame-rate images of the user's eyes and the reflection patterns, which are then analyzed by the mathematical image processing algorithms. They finally calculate the eyes' position and the gaze point on the computer monitor or on other visual stimuli.

By using this technique modern eye trackers are unobtrusive and require little activity from the respondents, allowing insights into natural viewing behaviors, thus producing implicit measures. Implicit measures are "measurement outcomes that reflect the to-be-measured construct by virtue of processes that are uncontrolled, unintentional, goal-independent, purely-stimulus-driven, autonomous, unconscious, efficient, and fast" (DeHouwer & Moors, 2007). While such methods tend to be less susceptible to manipulation than common explicit measures, they are nonetheless not immune to it, especially when participants are aware of the purpose of the experiment and have a general understanding of the mechanisms by which the result is produced (Steffens, 2004). Obese subjects, for example, are likely to guess that the goal of the experiment may be related to their body weight, prompting them to manipulate their gaze patterns to produce a more "favorable" result (e.g., avoid gazing at high-calorie foods). However, some of the commonly analyzed gaze metrics are harder to manipulate than others and hence, more reliable indicators of implicit attitudes, while others may represent controlled, explicit attitudes. Specifically, the former should be more prevalent in the early stages of visual processing (e.g., the direction of the first fixation or an initial pupillary response), while the latter should become evident in the later stages (e.g., as total fixation duration) (Duchowski, 2007).

The movements of the human eye can be characterized in several aspects: fixation, saccades, glissades, smooth pursuit, microsaccades, and tremors. Normally, eye-tracker devices are able to measure only some of these aspects (for examples and definitions see Table 12.1). It is well known that the human gaze does not move evenly over the observed object, but in the form of saccades by rapidly moving from one fixation in a certain location to another fixation in a more or less near location. These very short-lasting (20–80 ms) saccades are the fastest movements the human body can produce (Liversedge et al., 2011). Microsaccades, which are very small jumps between two fixations, are less understood, and it has been suggested that they are a fixation correction and control. During a saccade the observing individual is in fact blind, because vision is suppressed. Information about the visual stimulus is gathered during the fixation period only—therefore, only during a fixation, which varies in length from 100 to 600 ms, can the stimulus be seen consciously. Saccades are rarely linear but take several shapes and curvatures, and there exist also so-called postsaccadic movements (glissades), which can be seen as a kind of slight gaze wobbling around the fixation target. Moving objects can be followed by smooth pursuit, slow eye movements

TABLE 12.1 Definitions of Some Often Used Eye-Tracking Measures

Measure	Definition	Class
Time to first fixation	Time from starting the test until the start of the first fixation in an AOI (s)	Latency
First fixation duration	Time of the first fixation (s)	Time
Fixation count	Number of fixations within one AOI	Numerosity and position
Fixation duration (length)	Duration of each individual fixation within an AOI (s)	Time and position
Total fixation duration	Sum of all fixation durations of one participant within an AOI (s)	Time and position
Observation/visit/dwell count	Number of times that a participant enters an AOI	Numerosity and position
Observation/visit/dwell duration	Duration of each individual visit within an AOI (s)	Time and position
Total observations/visits/dwell durations	Sum of all visit durations for one person within an AOI (s)	Time and position
Fixations before	Number of fixations before the participant fixated within an AOI for the first time	Numerosity and position
Participant %	Percentage of participants that have fixated at least once within an AOI	Numerosity and position

AOI, area of interest.

(<30degrees/s) that stabilize the image of a slowly moving object on or near the fovea. Smooth pursuit eye movements are the second way to shift gaze, in addition to the saccadic eye movements for still objects. The human eye also shows a constant tremor, high in frequency (<80Hz) and low in amplitude, which avoids adaptation of the visual system (Hooge, Nyström, Cornelissen, & Holmqvist, 2015; Nyström, Hooge, & Holmqvist, 2013).

Many eye-tracking measures are derived from eye-movement parameters especially from saccades and fixations (see Table 12.1). They can also be assigned to one or two of the following four eye-tracking measure classes (Holmqvist, 2011):

1. Movement measures: dealing with all the variants of eye movements through space and their properties
2. Position measures: describing where an eye-tracked person has or has not been looking, and properties of eye movements at spatial locations

3. Numerosity measures: delivering numbers or proportions of any countable eye-movement event
4. Latency or time measures: expressing the duration from the onset of one event to the onset of a second event

A very intuitive visualization of eye-tracking data is the heat-map graphic illustrating the hot spots of visual interest. It shows the accumulated fixations (counts or lengths) of several participants on each area of the stimulus using a color code—often red stands for many (long) fixations and orange-yellow for medium and green for few (short) fixations. By limiting the time period being shown in the heat map one can create images for specific time slots, e.g., eye movements during the first 3 s when looking at a shelf. The example in [Fig. 12.1\(a\)](#) shows an ad of an Austrian confectionery manufacturer: a young woman in a beach situation holding the product in her right hand. The heat map clearly shows that the visual attention of the tested individuals was mainly focused on the face of the woman and the product. When an element of an ad is too dominant and attention grabbing, such as the face or the sex-appealing attributes of the subject, it is referred to as an “attention vampire,” meaning that it draws the attention from the product being promoted, like a vampire sucking his victim’s blood. An important tool for the analysis of eye-movement data is the use of areas of interest (AOIs) defining important areas of the image, which should be analyzed separately. AOIs can be drawn at the image using the eye-tracker software and then the eye-tracking data referring to the defined areas can be analyzed statistically. For instance, in [Fig. 12.1\(b\)](#) the product is defined as a rectangular and the face as an elliptical AOI.

Another option to visualize eye-tracking data is to depict fixations in a time line. Such gaze plots show the scan path and the search behavior of a participant. Each fixation is illustrated as a dot, the number in it stands for the order of the fixation’s occurrence, and the diameter of the dot represents the fixation length. [Fig. 12.2](#) shows an example for such a graphical presentation.



FIGURE 12.1A Example of a heat map to visualize eye-tracking data.

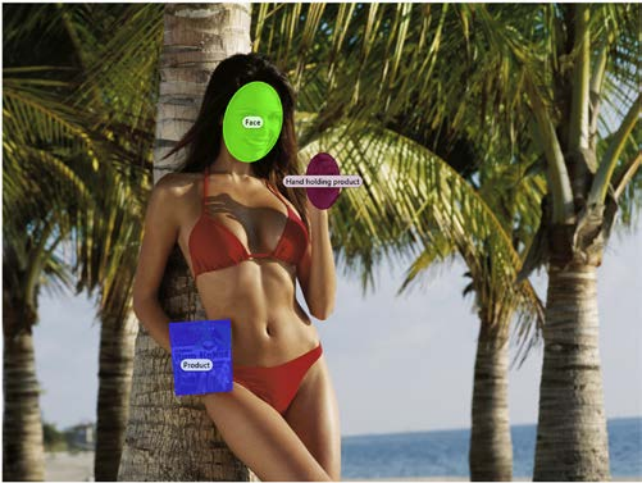


FIGURE 12.1B Definition of areas of interest within an image.

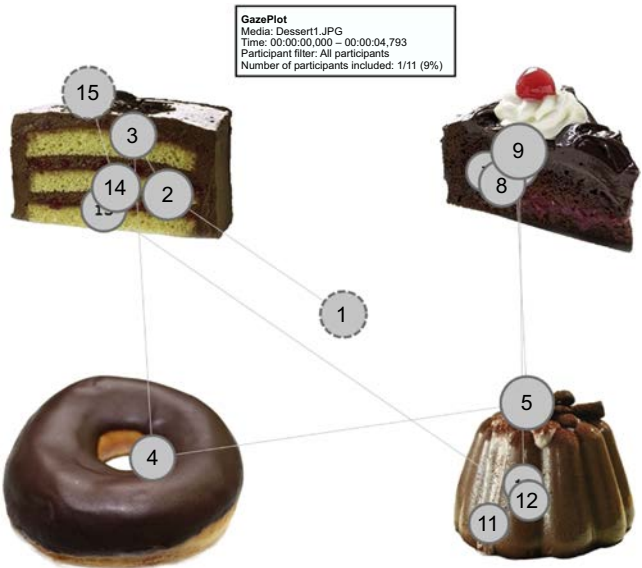


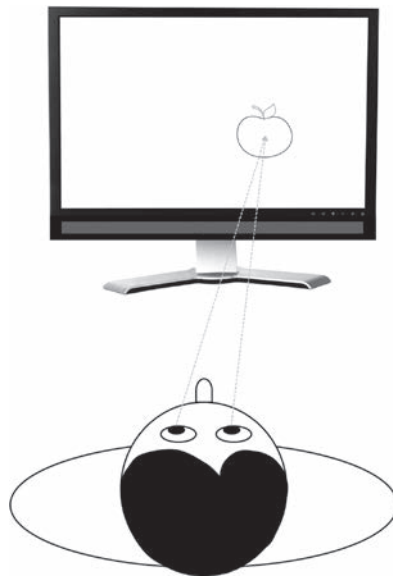
FIGURE 12.2 Example of a gaze plot to visualize gazing behavior.

2.2 Eye-Tracking Devices

Despite the fact that the first attempts to measure eye movements were already made by the end of 19th century, the development of eye-tracking systems did not proceed quickly. For more than 70 years researchers built their own systems, and only in the 1970s did companies begin to build and sell eye trackers for research (Holmqvist, 2011). Over the years, eye trackers

TABLE 12.2 Nonexhaustive List of Manufacturers of Eye-Tracking Systems

ASL, Applied Science Laboratories
iMotions A/S Biometric Research Platform
Interactive Minds Dresden GmbH
SMI SensoMotoric Instruments GmbH
SR Research (EyeLink)
Tobii Technology


FIGURE 12.3A Eye tracker in a monitor.

got cheaper and smaller, and nowadays, several commercial eye-tracking devices are available on the market (see [Table 12.2](#)). In general the devices can be grouped into three approaches. There are screen-based eye trackers, which use visual stimuli on a monitor and an eye-tracking module integrated into the monitor ([Fig. 12.3\(a\)](#)) or as a separate eye-tracking module, which can be mounted at the monitor. To investigate visual stimuli not on a computer screen but in the form of real objects, peripheral eye-tracking modules can be used while participants are sitting or standing still in front of the visual stimulus, e.g., shelves ([Fig. 12.3\(b\)](#)). Wearable eye trackers, often built into some kind of glasses, take this technology one step further and allow the recording of gazing behavior while participants can freely move around and interact with objects, e.g., shopping in the supermarket or driving a car ([Fig. 12.3\(c\)](#)).

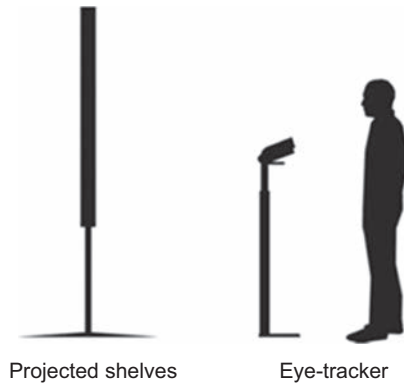


FIGURE 12.3B Eye tracker in front of a shelf (real or projected).



FIGURE 12.3C Wearable eye tracker from Tobii.

2.3 Factors Influencing Eye Movements

Factors influencing eye movements of humans are manifold, but there is extensive agreement that all these factors can be grouped into top-down and bottom-up factors. Bottom-up or exogenous factors come from the observed object itself, whereas top-down or endogenous factors emerge from the observing individual and his or her personal traits (Corbetta & Shulman, 2002). Bottom-up factors refer to eye movements elicited by diverse visual stimuli design factors (e.g., number of images, complexity of images, color, shape, and information level of images), whereas top-down factors refer to gazing behavior caused by aspects within the individual and his or her subjectively perceived task design factors (e.g., individual preference, decision goal, task instruction) (Orquin & Mueller Loose, 2013). Top-down or endogenous factors comprise the human being as such, his or her sociocultural background, health, gender, nutritional status, needs, goals, and beliefs. In the past, scientific research has focused more on top-down factors, but for several years bottom-up factors have been found to be of nonnegligible importance as well. Thus, it appears that gazing behavior is always influenced by both bottom-up and top-down factors; however, in certain test situations top-down factors are more influential than bottom-up factors and in others bottom-up factors dominate top-down factors clearly. Which factor group is more influential depends

on the design of the experiment regarding participants, task, and stimulus. There is an ongoing scientific discussion about the relative importance, relevance, and interactions of bottom-up and top-down processes influencing gazing behavior. On the one hand salient objects are able to attract attention irrespective of their relevance to the participant's goals, but this bottom-up effect seems to be short-lived (e.g., <150ms). Therefore, it is generally assumed that top-down processes such as goals or task instructions operating in later time windows override the effect of salience operating in early time windows. However, [Orquin and Lagerkvist \(2015\)](#) could not confirm this assumption, and in fact they found that the “maximum effect of salience on the likelihood of making a saccade to the target cue is delayed until about 20 saccades after stimulus onset and that the effects of salience and valence are additive rather than multiplicative.”

It is an early finding that eye movements depend on the question, including content and type of evaluation. [Alfred L. Yarbus \(1967\)](#) found that the content of the demanded test task may decide the pattern of eye movements. In his experiments, he presented the same picture and obtained different eye-movement patterns when asking participants different questions. More recent studies also found similar results by replicating the original experiments of Yarbus ([Glaholt, Wu, & Reingold, 2010](#); [Glöckner, Fiedler, Hochman, Ayal, & Hilbig, 2012](#); [Kim, Seligman, & Kable, 2012](#); [Toubia, 2012](#)). [Paulmann, Titone, and Pell \(2012\)](#) could even show that how instructions are given—they used different emotional prosodies—has an impact on gaze behavior.

Gazing behavior is influenced by the nature of task. In a math, logic, or geometry problem-solving task, participants sometimes look over several values, and sometimes make many rescans of some specific values, because they generate some form of mental spatial model to assist their logical induction, and they perform eye movements consistent with the spatial characteristics of that mental model. Moreover, visual working memory may store a surprising amount of information at any time, so participants need only some saccadic movements to record and analyze information in their mental spatial model ([Epelboim & Suppes, 2001](#); [Salvucci & Anderson, 2001](#)). In an insight problem-solving task, participants sometimes run out of ideas, they make several long gazes without making any moves, known as impasses. Participants seem to need this stage to look for solutions ([Jones, 2003](#); [Knoblich, Ohlsson, & Raney, 2001](#)).

Difficulty of task is another influencing factor on gazing behavior. [Hess and Polt \(1964\)](#) were the first researchers to find that a person's pupils dilate when solving a difficult task. As their multiplication problems got harder, pupil dilations steadily increased. More recently, [Knoblich et al. \(2001\)](#) and [Jones \(2003\)](#) found that in a difficult task mean fixation duration increased significantly. They explained this finding by the participants' need for impasse stages, in which cognitive processes search for solutions—the more difficult the tasks are, the longer the fixation time has to be.

It is well known that gender differences in gazing behavior exist when viewing sexual stimuli (Rupp & Wallen, 2007), but there is also some evidence for such differences in the food area. To test this hypothesis Duerrschmid and Haindl (2010) showed a series of pictures of increasingly spoiled food, and they found that women were able to detect signs of spoilage significantly earlier than men and showed longer fixation durations on the area of spoilage compared to men. So gender might also turn out to be a top-down factor influencing gazing behavior.

The cultural background of a person also seems to modulate visual attention toward food item images. Zhang and Seo (2015) investigated differences between North American and Chinese people in their gazing behavior toward food items with varying backgrounds. The background context, such as table setting and decoration, was varied in saliency, and the participants' visual attention toward the food itself decreased for both cultural groups with increased background saliency, as expected. However, Zhang and Seo (2015) also showed that Chinese participants looked at food items significantly later than the Americans, showing that Chinese participants were clearly more influenced by the background. Whereas Western persons "tend to look at visual stimuli more analytically, focusing on objects and their individual components, [...] Asian people pay more attention to contextual information such as background" (Zhang & Seo, 2015).

Spivey and Dale (2011) have demonstrated that eye movements are coextensive with cognition, and oculomotor processing is coextensive with cognitive processing. Depending on the demanded tasks, the cognitive processes vary, so eye-movement processes, which reveal cognitive processes, will change in the same way. Eye movements are reported as highly task dependent and linked to cognitive goals (Castelhano, Mack, & Henderson, 2009). The eye-mind hypothesis claims that the link between eye movements and cognitive processes does exist (Graham, Orquin, & Visschers, 2012). However, eye tracking tells only what people are gazing at, not why they are looking at it, which means that it does not tell us, at least not directly, about the underlying cognition processes leading to the eye movements.

Haindl and Duerrschmid (2010) investigated bottom-up factor attractiveness of food; they presented two series of five pictures of food from three product classes (fresh fruit, vegetables, and sausages) to the test subjects. These series contained one of five objects in different stages of spoilage, both ascending and descending compared to the four residual objects. The task of the experiments communicated to the participants was very vague: "Please have a look at the food images on the following slides and answer some questions about it." The relationships between food attractiveness and gazing behavior parameters can be described as U- or bell-shaped curve. For instance, the relation between fixation duration and attractiveness is U-shaped: disgusting food is gazed at much longer than good, but not very attractive, food and also clearly longer than very pleasant-looking food. These results support the finding of Turner and Silvia (2006), that "pleasantness is not necessary for

interest,” but also disturbing or disgusting stimuli may evoke interest. Many of such bottom-up factors have been investigated in the context of choice experiments as described in the following section.

2.4 Gaze Behavior, Choice, and Decision-Making

Decision-making is a complex behavior that is determined by many factors, including intrinsic stimulus characteristics; biological, physiological, psychological, situational, and sociocultural factors; and extrinsic stimulus characteristics, and the interactions between them (Köster, 2003, 2009). Eye tracking during decision-making provides a measure of the participants’ visual attention, a psychological factor. Because “cognitive resources of humans are limited, such that individuals cannot fully process all aspects of their environment at the same time, attention allocates processing resources to stimuli that are expected to be most relevant to an individual’s goals and well-being, facilitating adaptive behavior” (Reeck & Egner, 2015). For a long time the role of attention during decision-making was underestimated, because attention was considered as passively serving the decision process. However, in the 21st century, psychology has begun to acknowledge that attention plays an active role in constructing decisions and hence influences it by means of its own rules of working (Orquin & Mueller Loose, 2013). Attention is driven not only by endogenous or top-down processes like information demands, but also by exogenous or bottom-up processes and interactions with working memory. Decisions are made through complex interactions among stimuli, attention processes, working memory, goals, and preferences. In the decision-making process, two control mechanisms are often discussed, bottom-up (exogenous) and top-down (endogenous) control. Bottom-up control is commonly defined as stimulus-driven attention and top-down control is usually defined as goal-driven attention (Corbetta & Shulman, 2002). Also, most of the gazing behavior during decision-making involves both top-down and bottom-up processes. Several effects that have an impact on decision-making, such as consideration sets, information complexity, decision difficulty, etc., were explained by the interaction between attention and working memory. For example, increasing decision difficulty demands working memory resources, leading to more fixations (Fiedler & Glöckner, 2012; Krajbich, Armel, & Rangel, 2010; Krajbich, Lu, Camerer, & Rangel, 2012). In situations with increasing information complexity, participants tend to ignore some information in their decision tasks to reduce the relative amount of information observed. This allows decision-makers to make lower demands on attention and working memory by reducing maximal accuracy (Horstmann, Ahlgrimm, & Glöckner, 2009; Reutskaja, Nagel, Camerer, & Rangel, 2011).

“Not seen, not bought” and “What you see, is what you buy” are well-known proverbs of marketing experts. This raises the question of how choice in general, and food choice in particular, product properties, and visual attention are

associated. It has been demonstrated across different tasks that several gazing parameters are correlated with choice decisions. For a literature review on eye movements in decision-making see [Orquin and Mueller Loose \(2013\)](#) or [Glaholt and Reingold \(2011\)](#). Summarizing several eye-tracking studies, it was found that participants tend to have more fixations on the alternative they choose, a greater number of dwells, and longer total dwell duration (dwell duration is defined as the sum of fixation durations made on a stimulus before the decision-maker fixates on another area) ([Schotter, Berry, McKenzie, & Rayner, 2010](#); [Schotter, Gerety, & Rayner, 2012](#)). Furthermore, it is very likely that decision-makers have their last fixation on the chosen alternative and likely that the first fixated alternative is the chosen one.

Although the correlations between choice and gazing behavior have been studied for some time, only a few studies have focused on food choice in particular and the question whether gazing behavior is consistent across food categories ([Ares, Mawad, Giménez, & Maiche, 2014](#); [Danner, de Antoni, Gere, & Duerrschmid, 2016](#); [Gere et al., 2016](#); [Jantathai, Danner, Joechl, & Duerrschmid, 2013](#); [Krajbich & Rangel, 2011](#); [Reutskaja et al., 2011](#)).

The research on gaze behavior and decision-making has shown the following, very densely summarized results:

1. Eye movements during decision-making are partially driven by task demands.
2. Eye movements are influenced by the stimulus properties that bias information uptake in favor of visually salient stimuli (four major factors were identified: saliency, surface size, visual clutter, and position).
3. Eye movements do not have a causal effect on preference formation; however, there exist downstream effects on decision-making.
4. Eye movements are optimized to reduce the demand on working memory, the number of fixations, and the length of saccades.
5. Drivers of eye movements in decision-making change dynamically within tasks, across time, through learning and utility effects and task instructions and also through several attention phases (e.g., overview, finding, comparison, checking) ([Orquin & Mueller Loose, 2013](#)).

Decision-making as such is a very complex topic, which was described by Edmund T. Rolls, in its several relevant processes and their interactions within the human brain, such as memory, emotion, attention, etc., from a neuroscientist's perspective ([Rolls, 2008, 2013](#)). It is also worth noting here that Joseph LeDoux and Antonio Damasio have shown that the decision-making process is obstructed by a lack of emotional interpretation of cognitive information: no emotion—no decision ([Damasio, 1994, 2000, 2003](#); [Ledoux, 1998](#)).

The relationship between consumers' gazing behavior and their decisions has been revealed in research using eye-tracking techniques. Several studies showed that the chosen alternative is looked at longer and more often than other alternatives. [Pieters and Warlop \(1999\)](#) found that when we make decisions we

often spend longer examining options that we ultimately choose than those we do not choose. [Armel, Beaumel, and Rangel \(2008\)](#) reported that the relative amount of time that subjects fixated on an item during a decision-making process increased the probability of choosing. [Krajbich and Rangel \(2011\)](#) found that the multialternative drift–diffusion model provides a quantitatively accurate description of the relationship between choice, reaction time, and visual fixation data by investigating gazing behavior during a trinary choice task using food products with different liking ratings as stimuli. In the study of [Graham and Jeffery \(2012\)](#) 203 participants viewed 64 food items on a computer screen equipped with an eye-tracking camera, simulating food purchasing decisions. Participants spent more time looking at labels for products they decided to purchase compared to those they decided not to purchase. In line with these results [Jantathai et al. \(2013\)](#), [Gere et al. \(2016\)](#), and also [Danner et al. \(2016\)](#) showed that fixation count and visit duration had a significantly positive correlation with choice rate. The 2015 study of [van der Laan, Hooge, de Ridder, Viergever, and Smeets \(2015\)](#) found that total fixation duration was determined by the decision goal and the preexisting preference. Their participants fixated on the chosen product longer than the not chosen. In brief, it has been demonstrated in several studies that some gazing parameters are correlated with choice rates in an eye-tracking test. [Gere et al. \(2016\)](#) also presented statistical choice prediction models based on gazing data and identified the Iterative Dichotomiser 3 algorithm as the best model to describe the relationship between visual attention and food choice.

Previous eye-tracking studies demonstrated that stimulus-driven attention plays a role in decision-making that should not be neglected. Several observations were made, such as attention being captured by salient stimuli ([Bialkova & van Trijp, 2011](#); [Milosavljevic, Navalpakkam, Koch, & Rangel, 2012](#)), surface size ([Chandon et al., 2009](#)), visual clutter ([Visschers, Hess, & Siegrist, 2010](#)), and position ([Chandon et al., 2009](#); [Chen & Pu, 2010](#); [Shi, Wedel, & Pieters, 2013](#)). These observations relate to bottom-up control of attention. The bottom-up processes lead to downstream effects on choice, in that alternatives that capture more attention will be more likely to be chosen. Furthermore, according to the parallel constraint satisfaction model, the influence of bottom-up processes on decision-making is approved because salient alternatives have a higher level of initial attractiveness; they are, *ceteris paribus*, more likely to be chosen ([Glöckner & Betsch, 2008](#)). This decision model predicts that the favored alternative or most important attribute receives attention ([Orquin & Mueller Loose, 2013](#)).

According to several decision theories, goal-driven attention plays a significant role in decision-making. Attention is influenced by goal-driven attention factors such as task instruction, utility effect, heuristics, and also learning effects. They relate to top-down control of attention and indicate an underlying principle: decision-makers preferentially direct their attention to goal-relevant stimuli. For example, in many different tasks the utility

effect has been demonstrated, which means that participants tend to gaze at information with a greater utility or importance to their decision. Other research showed that participants have more fixations on their chosen alternative (Glöckner et al., 2012; Kim et al., 2012), longer first fixation duration (Glaholt & Reingold, 2012), and longer first dwell duration (Glaholt & Reingold, 2012; Schotter et al., 2012). Attributes with a greater importance to the decision-maker also receive more fixations (Glöckner et al., 2012; Kim et al., 2012), and alternatives with a higher mean expected value receive more fixations and longer fixation durations (Fiedler & Glöckner, 2012). These findings have been explained by the interactions between visual attention, decision-making, and cognitive processes.

It is clear that, depending on the task, cognitive processes will change, and eye movements will follow and reveal the change in cognitive processes. This conclusion suggests that task design in an eye-tracking test may influence directly the recorded results. In a systematic research study various possible influencing factors on eye-tracking measures were investigated by Vu, Tu, and Duerrschmid (2016). It was demonstrated that consumer gazing behavior is strongly influenced by the type of evaluation (five types of evaluation: maximum choice, minimum choice, ranking, rating, and grouping) and the number of images shown per picture (2, 3, 4, 5, or 6 images per picture), but not influenced by the content of questions (about five aspects of food: deliciousness, healthiness, price, convenience, and familiarity). A significant correlation between choice and gazing behavior parameters was found only when the type of evaluation was of a maximum or minimum choice kind (e.g., Which is the healthiest product? Which is the least healthy product?). In the maximum choice test, by varying the *content of questions*, the *number of images* (from 3 to 5), and the *content of images* separately, both investigated gazing behavior parameters (*total fixation duration* and *fixation count*) correlated significantly in a positive way with the choice rate.

3. APPLICATIONS

3.1 Eye Tracking in Packaging and Label Design

In the modern food supply chain packaging plays an important role in stimulating consumers' wanting of products and delivering important information to them about the identity, brand, nutritional and other quality aspects, and use and functions of the packaged food product (Ares & Deliza, 2010; Bialkova et al., 2014). Packaging also gives room for advertising, labels, pictures, and colorful signs, which assign meaning to the products and make them as appealing to consumers as possible. The packaging design frames the cloud of attributes in which the producers want their product to be perceived. Packaging and label design elements elicit memories, associations, emotions, and also expectations regarding the consumer's degree satisfaction

during and after consumption. This leads to a more or less intense feeling of wanting the product. The expectations are often based on former experience with similar products in their packaging; incidentally we learn every day which quality cues on the packaging or label indicate which quality attributes. [Steenkamp \(1989\)](#) describes this process of perceiving product quality in detail and makes clear that packaging is a critical factor in the consumer's decision-making process. How consumers perceive packaging depends on the various communication elements, which become the key to success for many marketing strategies ([Silayoi & Speece, 2004](#)).

These considerations are the basic cause of why so many published studies have examined gazing behavior toward packaging and food labels ([Antúñez et al., 2013](#); [Ares et al., 2013](#); [Ares, Mawad, et al., 2014](#); [Bialkova et al., 2014](#); [Bialkova & van Trijp, 2010](#); [Oliveira et al., 2016](#)). For a review regarding eye tracking and nutrition labels see [Graham et al. \(2012\)](#). Eye tracking can help to develop label and packaging designs that “improve consumers’ ability to locate and effectively utilize nutrition information” to select healthful foods ([Graham et al., 2012](#)). However, the packaging and label design can also direct the consumers’ attention to other quality aspects of the food product, like sustainability or sensory properties.

Eye-tracking techniques are largely applied in food packaging research. By recording the dwell times and the areas that consumers pay attention to, eye tracking can determine how packaging influences consumer attention. Some studies have used a free-viewing task but varied stimulus-driven attention to study how packaging attributes (layout, nutrition label, etc.) affect consumer gazing behavior and then suggest how to develop an appropriate packaging design ([Piqueras-Fiszman, Velasco, Salgado-Montejo, & Spence, 2013](#); [Rebollar, Lidón, Martín, & Puebla, 2015](#); [Siegrist, Leins-Hess, & Keller, 2015](#)). Some others have conducted a specific task, such as evaluating the healthfulness of a product or willingness to purchase or try a packaged product, to study goal-oriented attention ([Ares et al., 2013](#); [Ares & Jaeger, 2013](#); [Bialkova & van Trijp, 2011](#); [Graham & Jeffery, 2012](#); [van Herpen & Trijp, 2011](#)).

[Samant and Seo \(2016\)](#) studied the effect of label knowledge on “consumers’ purchase behavior, measured with respect to their visual attention to label claims on chicken products.” They found that people with high label knowledge looked at label claims associated with sustainability and process more often and longer than those with low label knowledge, whereas people with low label knowledge examined the appearance of the meat products more often and longer than those with high label knowledge. Furthermore, participants with high label knowledge liked and trusted the chicken products significantly more than those with low knowledge. This means that enhanced label knowledge seems to increase consumers’ visual attention to labels, but also expected liking and trust, which is likely to influence their purchase behavior.

[Antúñez et al. \(2013\)](#) investigated Uruguayan consumers’ visual processing of food labels during the evaluation of the salt content of pan bread labels

and they also studied the influence of label design and nutritional labeling format on consumers' attention with eye-tracking techniques. Participants had to decide "whether the sodium content of each label was medium or low, while their eye-movements were recorded using an eye-tracker." Most of the participants looked at nutrition labels and a traffic light system to evaluate the salt content. However, the average percentage of participants who looked at the actual sodium content was low. Nutrition information format clearly affected participants' processing of nutrition information: the traffic light system increased participants' attention to nutrition information and facilitated its processing, but not its understanding (Antúnez et al., 2013).

Food labels previously unknown to consumers were investigated by Ares et al. (2013) to answer the question, which areas of the labels were of importance to them in evaluating willingness to purchase and the perceived healthiness of the food product. The results showed that the attention paid to such unfamiliar food labels was mainly determined by top-down factors. Consumers scanned the labels and searched for specific information related to brand, composition, and nutritional information.

Visual attention, which is a prerequisite for perceiving and comprehending visual information, is influenced by motivation and by ability independently. This means that both factors influence the comprehension of information, and increasing only the ability to comprehend nutritional information affects the consumer's behavior independent of his or her motivation. Although motivated individuals are most likely to benefit from better labels, persons with a low health motivation also benefit from labels with an enhanced visibility. Therefore, it seems much easier to increase the ability to comprehend label information compared to increasing motivation in a relevant dimension. To reduce barriers to comprehending nutrition information on labels, eye-tracking research has identified several label characteristics, whose manipulation can enhance consumers' ability to locate and comprehend the labels with the goal to make healthful food choices (see Table 12.3).

Bialkova and van Trijp (2010) found, in addition to this list of influencing label characteristics, that visual attention is enhanced more by mono- than by polychromatic coloring and they also found a familiarity effect: the ability to use the label was better when "the type of label and its location on the package did not change in two consecutive exposures, suggesting that nutrition logos should be printed in a consistent location on the package." van Herpen, Seiss, and van Trijp (2012) showed in the example of the United Kingdom and the Netherlands that familiarity with particular labeling schemes mediates label evaluations. Therefore, consumer evaluations of labeling schemes may be specific to the market where they are collected and such findings should not be generalized to markets with different label familiarity patterns. This aspect is also emphasized by Antúnez et al. (2013), who did their work in the Uruguayan market.

Siegrist et al. (2015) also investigated how different labeling systems [nutrition table, guideline daily amount (GDA), traffic light (TL) format]

TABLE 12.3 List of Ability-Improving Label Characteristics

Label Characteristic	Ability Improves With	References
Location of the label	Central position of the label	Graham and Jeffery (2011)
Location in the label	Ranking of the nutrients according to their health relevance	Graham and Jeffery (2011)
Visual clutter	Reduction of visual clutter around the nutrition label	Bialkova, Grunert, and van Trijp (2013) and Visschers et al. (2010)
Visual salience	Increase of the visual salience of the nutrition label (color, contrast, orientation)	Itti, Koch, and Niebur (1998)
Surface size	Increase of the surface size of the nutrition label	Peschel and Orquin (2013)

influence consumer gazing behavior. Participants had to evaluate the healthiness of five foods from different food categories and their eye-tracking data suggested that they needed more time to process the GDA format in comparison to the TL and the nutrition table format. Participants were able to process the TL format more efficiently than the nutrition table, and there were no substantially different evaluations of the healthiness of the food products between the GDA, the TL, and the nutrition table formats. These results led Siegrist et al. (2015) to the clear conclusion that the TL format was better than the other two formats, guaranteeing a consumer-friendly way of communicating nutrition information.

Consumers' attention to functional food labels was investigated by Oliveira et al. (2016) using eye tracking combined with a word association task. The consumers' visual behavior when looking at the label designs (different in brand, type of product, type of microorganism, and health claim) was not largely influenced by the type of the product and the label design; however, the graphic design of the labels played a key role in influencing health-related associations.

In a choice experiment combined with eye tracking, Bialkova et al. (2014) explored whether and how attention to nutrition information mediates consumers' choice. Consumers were asked to choose the healthiest product or the product of their preference. The products showed a choice logo, a monochrome GDA label, or a color-coded GDA label. Respondents fixated longer and more often on products with color-coded GDA labels than on products with monochrome GDAs or choice logos. A health goal resulted in longer and more frequent fixations compared to a preference goal. Products with color-coded and

monochrome GDAs had the highest likelihood of being chosen, and this effect was related to the attention-getting property of the label (irrespective of brand and flavor effects). Furthermore, the product fixated on most often had the highest likelihood of being chosen. These results suggest that attention mediates the effect of nutrition labels on choice.

Ares, Mawad, et al. (2014) investigated the top-down factor thinking style (rational vs. intuitive) regarding choice and visual information processing when evaluating yogurt labels. They varied the label design in the form of a 2^3 factorial design with fat and sugar content, background, and TL system as the influencing factors. Gazing behavior parameters differed significantly and strongly between the two thinking style groups for almost all AOIs except for the TL system. Analytically thinking consumers in general made a greater information search and showed more thoughtful analysis of nutritional information for making their choices than intuitively thinking consumers. However, the authors emphasize that “personal and contextual factors modulate the extent to which consumers rely on the two modes of thinking for making a decision and how they process available information.” To these factors belong the personal relevance of task and decision, motivational goals, product involvement, available time, purchase situation, and familiarity. So thinking style appears to be only one of many factors underlying attention and choice behavior, and future research has to clarify its relative influence compared to other product, personal, and contextual characteristics.

3.2 Eye Tracking in Menu Design

Menu design aims at conveying information to customers so that they are able to choose an appropriate meal. It is clear that an item that is not seen on the menu will not be ordered. However, just knowing that an item is offered does not ensure it is ordered to a certain frequency—increased item awareness does not significantly increase purchase likelihood (Reynolds, Merritt, & Pinckney, 2005). Recommendations for the design and layout elements of menus have long existed to make items better perceivable or more memorable. Increased promotion of items through design can be reached by the items being boxed or highlighted (Hug & Warfel, 1991; Hunt-Wesson-Foodservice, 1999; Stoner, 1986), placed at the top or bottom of a list, or placed in areas of the menu through which the guests’ eye movements pass most frequently (Gallup-Report, 1987). These recommendations are based on the serial position effect (rules of recency and primacy) (Ditmer & Griffin, 1994; Miller, 1992; Pavesic, 2011) and the von Restorff or isolation effect (von Restorff, 1933), two well-known effects in psychology. The serial position effect describes that people are better able to recall the first (primary) and the last (most recent) items in a list (McCrary & Hunter, 1953), whereas the von Restorff effect refers to a person’s ability to recall distinctive items differing from the rest better than the nonstriking others (Hunt, 1995). However, all the recommendations to the practitioners

have not yet been validated empirically. Eye-tracking experiments of [S. S. Yang \(2012\)](#) with 25 participants from her university showed that on average people made their initial reading of a two-sided menu in quite a consistent manner. The area at which participants look first is the upper left corner of the first page. In principle they read the two-sided menu like a book, starting on the top of the left page, looking down to the end of the first page, then moving to the top of the second page, and following the same top-down reading pattern. Yang also found that participants followed a certain strategy of building a meal. First they scanned the lighter fares and entrees, and after choosing the entrées they proceeded to build a meal around the entrée. Fixation durations decreased for menu items on the second page. All food items were read on the first pass, but entrees most carefully. However, perhaps consumers use several different information-gathering tactics. No sweet spots, areas on the menu where participants have more fixations, have been found, but there appear to be so-called “sour spots,” which are areas of the menu where participants have significantly fewer fixations: the bottom area of each page. For Yang it is still not clear whether attention and memorability affect choice or not: “Perhaps preference determines choice only after attention has narrowed the number of options.” She concludes that systematic scientific menu research has just begun.

3.3 Eye Tracking in a Supermarket

A supermarket is a very complex, multisensory situation in which consumers are tempted to make unplanned purchases ([Otterbring, Wästlund, & Gustafsson, 2016](#)). Because a considerable percentage of all the food we eat is purchased in supermarkets, research in this field is of utmost importance and of course eye tracking can also contribute to elucidating consumers’ behavior in this situation. Some product developers say that the main reason new product launches flop is simply the fact that they are not considered at the shelf—“unseen is unsold” ([Wedel & Pieters, 2008a](#)). Depending on the product category 50%–70% of purchase-related decisions are made at the point of sale in the supermarket ([Hoyer, MacInnis, & Pieters, 2012](#)). Because the number of products in a normal supermarket can easily reach 20,000 items and because the shopping time of consumers is only up to 30–45 min, the time for consumers to consider a product for purchase is very restricted: for low-involvement goods like food products the decision at the point of sale, which is mainly driven by sensory pulses and emotions ([Lehrer, 2009](#)), has to be made on average within 2–3 s, with a maximum of 7 s ([Hamaekers & Depoortere, 2010](#)). Therefore, it is extremely important for a product to be visible on the shelf of the supermarket to optimize sale numbers.

Of course, seeing a product does not mean buying it, but the visual perception is a necessary first step. The visual coding leads to visibility and identification of the product and a primary affective reaction toward it. After this affective reaction, which is based on memories of experiences in the past, more or less rational cognitive processes take place, in which consumers

realize the brand block value and get the main messages and claims and the product features. This cognitive step is again followed by an affective reaction resulting in buying intention and buying behavior. So the “first moment of truth,” which grabs attention, touches emotionally, and triggers positive expectations, is of high importance for a product to be considered for purchase. However, it has to be emphasized that there is always a “second moment of truth,” which takes place during the usage phase, when the elicited expectations meet the actual usage experience. This evaluation process leads to more or less satisfaction and to a more or less likely repurchase, when in the next relevant purchase situation the satisfaction or dissatisfaction experienced influences the process of decision-making (Antonides & Van Raaij, 1999; Hamaekers & Depoortere, 2010).

Shelf tests are mostly performed to investigate the visibility of products on the shelf position. For that purpose an eye tracker is positioned right in front of a real or a projected shelf containing products and the gazing behavior of consumers is measured. Several studies have also investigated consumers' gazing and choice behavior in the very near to life situation in supermarkets by using mobile eye-tracking devices. The tasks of the tests can be different; they can relate to perceptual or conceptual features of the product. Perceptual feature tests show whether the packaging is communicating the message it is supposed to communicate, whereas conceptual feature tests refer to the mental picture of a product, brand, or category (Tobii, 2008). Questions to be answered may be, for instance: How long does it take for the shopper to find the product and what is the average viewing pattern on the shelf? Where did eyes stop first? How many of the products on the shelf are noticed? How many persons looked at a certain product first? Is a certain product able to pull attention quickly? How does the finding time change when product properties like color or shape are changed? Which products have competing properties and how can the studied product be distinguished from them? The description of the test and the information given to the participants have to be considered properly, e.g., “You want to buy ketchup; look for the variant you would go for,” “Look for an exclusive (cheap, healthy, etc.) product”; and also time restrictions can be defined using tachistoscopic techniques.

On-shelf assessments clearly show that the position of the product on the shelf is of high importance. Products placed at the arm level gain maximum visibility; at the eye level visibility is reduced c.10%; bottom shelf means a decline in visibility of c.20%, and above the eye level there is already a decline in visibility of c.30% (see Fig. 12.4) (Depoortere, 2009). So knowing that being seen is an important prerequisite of being chosen, and knowing that there exists a strong positive correlation between shelf visibility and purchase intention, there is also a strong pressure to design products for high visibility, which catches the attention of bypassing consumers. How can visibility be enhanced? In general visibility is a matter of contrast. Contrast can be reached via the shape and color of the packaging, the logo, the size of the product, or the promo on the pack.

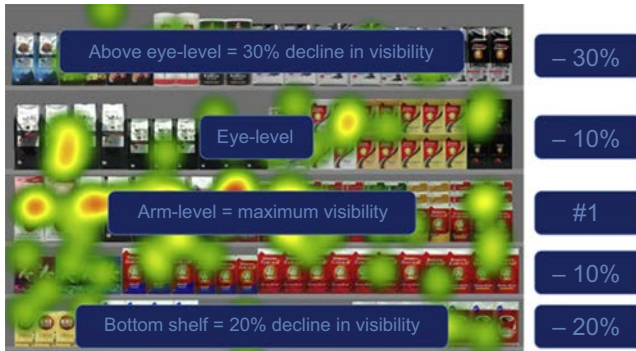


FIGURE 12.4 Visibility of products depending on the position on the shelf (Depoortere, 2009).

Orientation or movement may also function as contrast enhancers, but they are not used in the supermarket setting so far. Particular, unique shapes attract attention, as well as prominent logos in an appropriate size, shape, and color. Visibility is enhanced by striking and contrasting colors on the shelf, but also by maximizing shelf space for one product. A measure for the effectiveness of visibility is the proportion of attention percentage of the product (related to the other products) versus the percentage of shelf space needed to gain this attention (Depoortere, 2009).

In addition to visibility, recognition and “findability” are also important aspects to be optimized in shelf tests. It has to be ensured that consumers find the product they intend to buy (Wedel & Pieters, 2008a). Facilitating the shopping experience has a positive effect on purchase numbers. Consistency in the design, layout, and development of a house style makes products more easily identifiable and recognizable, and promotion material at the point of sale supports findability.

With the development of mobile eye trackers it is also possible to measure and analyze the consumers’ gaze during their walk through the supermarket, along the shelves, sales counters, product islands, and sales booths within the market.

3.4 Emotions and Eating Disorders

The measurement of emotions is a problem that has created a wide field of scientific research and publications. Sensory and consumer research is increasingly interested in emotions, because they are thought to give additional insights into the development of human food-related behavior and to complete the picture of food intake regulation. In addition to different kinds of questionnaires, several instrumental methods have been developed and tested to investigate emotional reactions, e.g., the measurement of changes in the autonomic nervous system (e.g., heart rate, skin conductance), electromyography, and automatic analysis of facial expression (also the topic of Chapter 10 in this book). Analyzing eye

properties via eye tracking as an automated method to find a measure of human emotions is seldom used. [de Lemos, Sadeghnia, Olafsdottir, and Jensen \(2008\)](#) have proposed an application of eye tracking as a nonintrusive measurement of emotional response. Their software algorithms were developed to analyze eye-tracking data regarding subtle changes in gaze, blink, and pupil characteristics to determine basic low-level emotions. Gaze patterns might give a hint of emotional reactions, and pupil dilation is already known to be related not only to the general cognitive load and the intensity of light, but also to the intensity of emotional reactions ([Bradley, Miccoli, Escrig, & Lang, 2008](#); [Granholm & Steinhauer, 2004](#); [Partala & Surakka, 2003](#)).

[Jiang, Wang, and Yu \(2015\)](#) have presented an expressive eye model, in which they use eye movements to model and display basic emotions of humans with eyes. For that purpose they not only use the movements of the eyeballs (amplitude, direction, and duration of saccades), but also the movements of the eyelids (amplitude, duration, lid position, and blink rate). Using eye tracking they investigated eye movements under the influence of six basic emotions and found clear differences in three parameters: duration of eye saccades (sad longest duration, angry shortest duration), position difference between eyelid and eyeball (highest for surprise and lowest for sad), and also blink rate (highest for sad and lowest for happy). Thus they assume that these three parameters can be used to model emotional expressions in eyes. In return to their approach it should also be possible to characterize the reflections of emotions in a person's eye.

The emotion topic in eye tracking can also be approached from the opposite side: how do emotions and mood influence gazing behavior? [Frayn, Sears, and von Ranson \(2016\)](#) showed, for example, that sad mood increases the attention to unhealthy food images in women with food addiction.

[Armstrong and Olatunji \(2012\)](#) reviewed eye-tracking research on anxiety and depression, and they concluded that relative to a control group, anxious individuals show increased vigilance for threat during free viewing and visual search. Anxious persons also show difficulty in disengaging from threat in visual search tasks, but not during free viewing. Depressed individuals “were not characterized by vigilance for threat during free viewing, but were characterized by reduced orienting to positive stimuli, as well as reduced maintenance of gaze on positive stimuli and increased maintenance of gaze on dysphoric stimuli.”

The attentional effects of learned implicit attitudes have been investigated in several studies on restrained eating behaviors: according to [Stewart and Samoluk \(1997\)](#), chronic dietary restraint significantly affects latencies in a Stroop task, while acute food deprivation (an induced hunger state) does not. [Hoefling and Strack \(2008\)](#) used an Extrinsic Affective Simon Task to analyze implicit attitudes toward foods of varying caloric densities among a group of restrained eaters, reporting a clear discrepancy between implicit measures and

explicit ratings of high-calorie foods, but not low-calorie ones. Combining eye tracking with a dot-probe task, [Castellanos et al. \(2009\)](#) reported that, while both obese and normal-weight women showed increased gaze duration on food versus nonfood images in the hunger condition, only the obese also exhibited this bias in the sated condition; there were no significant differences between groups in terms of reaction times, however.

Combining gaze tracking and pupillometry, [Graham, Hoover, Ceballos, and Komogortsev \(2011\)](#) investigated the relationship between food-related gazing behavior, body mass index (normal vs. overweight/obese), state of hunger, state and trait craving scores, and restrained eating behaviors. Their findings seemingly contradict those of [Castellanos et al. \(2009\)](#): specifically, they did not find a statistically significant correlation between either state of hunger or state craving scores and average fixation durations on food images. A possible explanation for these discrepancies is provided by the elaborated intrusion theory of desire ([Kavanagh, Andrade, & May, 2005](#)), which posits that the “seemingly spontaneous and intrusive thoughts that ultimately underlie cravings and subsequent consumption may be more likely to arise while cognitive resources are low and attention is divided” ([Graham et al., 2011](#)). Whereas [Castellanos et al. \(2009\)](#) employed a dot-probe task that required a significant attentional commitment, [Graham et al. \(2011\)](#) used a free-viewing paradigm, which—while approximating a “natural” viewing situation—did not require a significant diversion of attention, and may thus have been more susceptible to an intentional manipulation of gaze patterns. Additionally, self-report measures including pointed questions concerning the participants’ eating habits and state of hunger and a lack of nonfood images may have further exacerbated the influence of their explicit food attitudes on fixation durations. Another explanation lies in the role of highly specific learned associations in craving states, which vary widely between individuals and demographics, leading to poor comparability between studies with small sample sizes from distinct social or ethnic demographics.

Bogus tasks and additional attentional paradigms carry their own risks, however. Blatantly obvious attempts at obfuscation or unnecessarily complex tasks may annoy or frustrate the test subjects, negatively affecting their compliance with instructions or deterring them from participating altogether. Even if appearing plausible to participants, the task may also present a situation in which they feel they can “win” or “lose,” making them more likely to try to influence their gaze patterns to increase memory retention; some participants may also experience unnecessary stress. In addition to constituting an ethical problem, particularly when working with participants undergoing treatment for obesity-related health issues, stress is also known to increase both perceived hunger and attention bias to high-calorie snacks, making it a confounding factor to be avoided ([Habhab, Sheldon, & Loeb, 2009](#); [Hepworth, Mogg, Brignell, & Bradley, 2010](#)).

4. CASE STUDY: VISUAL ATTENTION AND CHOICE BEHAVIOR IN MULTIALTERNATIVE FOOD CHOICE SITUATIONS

With the example of a 2016 study ([Danner et al., 2016](#)), we present how eye-tracking technology can be applied to investigate food choice behavior and will discuss aspects that should be taken into consideration when planning and conducting eye-tracking experiments.

To investigate the relationship between gazing behavior and choice decision, the gazing behavior of 59 participants was recorded during the decision-making process of a multialternative choice task. Nine choice sets, consisting of pictures of four product alternatives each, were presented on the screen of a Tobii T60 eye tracker (Tobii Technology AB, Sweden), and the participants' task was to choose the product that appealed most to them of the four alternatives, without a time limit. A warm-up choice set was presented to familiarize the participants with the task and the procedure. The recordings of the warm-up sample were excluded from the data analysis. The remaining eight choice sets represented different product categories, including apple, beer, bread, chocolate, instant soup, salad, sausage, and soft drink (see [Fig. 12.5](#)). The selection of the product pictures was based on a pretest with 40 participants of age similar to that of the participants in the main test, investigating visual appearance, product familiarity, and liking. Four products of each category with high and comparable familiarity as well as liking ratings were chosen for the main study. Special care was taken to select pictures of good quality, comparable lighting, and size, as those factors potentially bias participants' gazing behavior. To control for position effects, e.g., the tendency to fixate first on objects in the top left position ([Reutskaja et al., 2011](#)), the positions of the products were randomized across participants.

For data analysis, six gazing parameters, including time to first fixation, first fixation duration, fixation duration, fixation count, total dwell duration, and dwell count, were calculated for each product using Tobii Studio software (version 3.0.5, Tobii Technology AB). As decision times varied across participants, a within-subject design using repeated-measures analysis of variance was applied, with the eye-tracking parameter as the dependent measure, product variant as the within-subject factor, and the stated choice as the between-subject factor.

The results showed a strong correlation between choice probability and visual attention in the form of fixation count, dwell duration, and dwell count (see [Fig. 12.6](#)). If an alternative received more visual attention compared to chance alone, the probability of being chosen was substantially increased. Additionally, it was found that the last fixated alternative was significantly more often chosen than expected by chance. On the other hand, no increase in choice rate was observed for the first fixated product, supporting the findings of [van der Laan et al. \(2015\)](#). However, it still seems worthwhile to investigate first fixation effects in more complex choice situations, because the effects of first fixation under these conditions are still unclear, e.g., decision-making



FIGURE 12.5 The eight presented choice sets, from top left to bottom right: apple, beer, bread, chocolate, instant soup, salad, sausage, soft drink.

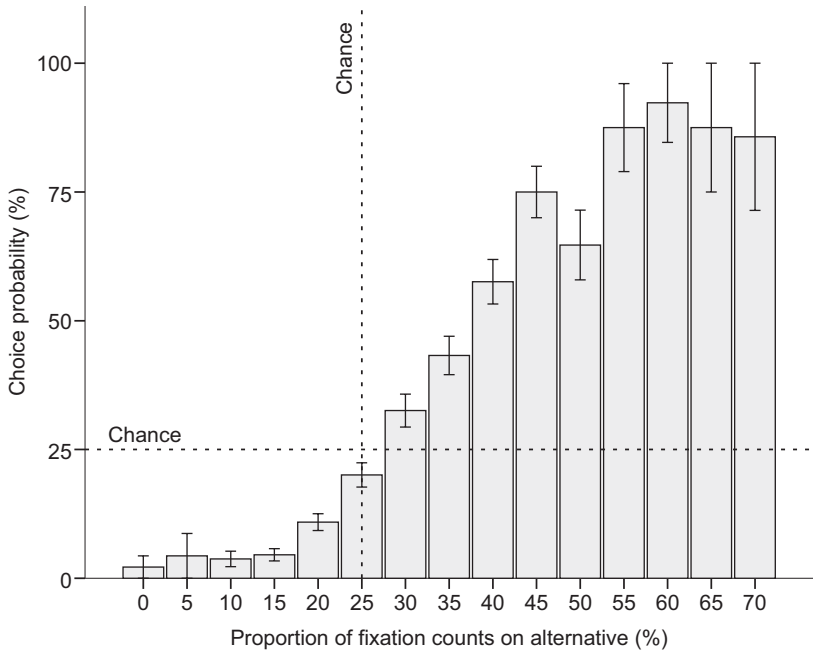


FIGURE 12.6 Relationship between visual attention in terms of fixation counts and choice probability for four alternative choice situations, pooled over all samples (59 participants and 6 product categories). Error bars indicate standard errors.

under time pressure, choice in a supermarket (with its overwhelming number of product alternatives making it almost impossible to consider each available alternative), or situations with reduced attention.

Investigating the different product categories, it was found that the results were consistent across all tested choice sets (different product categories) and clearly showed the same effect in that the chosen alternatives received more visual attention in the form of higher fixation counts, longer total dwell duration, and more dwell counts. These findings are in accordance with the findings of [Orquin and Mueller Loose \(2013\)](#) and [Jantathai et al. \(2013\)](#).

In a further study 13 different statistical models were compared regarding their performance in predicting participants' choice solely based on participants' gazing behavior ([Gere et al., 2016](#)). The results showed that the statistical models gave very accurate predictions of choice, with the best models showing an accuracy of up to 94.9% across all tested product groups, clearly demonstrating the close relationship between gazing behavior and choice in forced multialternative choice tasks.

Future studies might build on the close link between gazing behavior and choice to investigate the influence of participants' hunger state, eating behavior, eating disorders, and body mass index, but also aspects of product design, on gazing behavior and choice decisions.

5. LIMITATIONS

Although modern eye trackers generally allow very accurate and robust measurement of gazing behavior, there are several limitations of technical as well as methodical nature that need careful consideration when planning experiments or interpreting results derived from eye-tracking studies.

Despite all the technical advances eye trackers do not work well for every participant. Glasses in general do not bias the measurement of modern eye-trackers (as long as the same glasses were used for calibration); however, glasses with progressive lenses may interfere with the measurement. Although it is possible to track each eye individually during an eye-tracker experiment, participants with strabismus or amblyopia (lazy eye) may cause inconclusive results.

A very general limitation is the availability or the relatively high price of eye-tracker equipment and the need for experienced technicians to set it up, therefore limiting the application in real-life situations such as home-use tests.

Data gained in an eye-tracking experiment can also be biased, if participants are aware of the testing situation and the goals of the experiment. They may then move their gaze consciously and deliberately to areas of the picture that they consider to be most appropriate or socially desirable, and this is exactly not what an implicit test wants to study. So the experimenter has to be experienced enough to create a test situation in which unbiased and near-to-life eye movements occur. It is easy to conceal the monitor-based eye tracker, because such eye trackers simply look like normal PC monitors; however, when it comes to wearable eye trackers every test person will realize that he or she has to wear the glasses-like eye tracker and therefore will guess the purpose of the test. So, in one way, wearable eye trackers are nearer to life than other eye-tracking solutions, because test persons can move in real-life situations such as a supermarket or restaurant, but on the other hand, the gained data may be biased by the fact that the participating individuals behave differently because they know that their gazing behavior is observed.

Furthermore, the application of wearable eye trackers also complicates processing and analyzing of the collected data substantially, as wearable eye trackers map the gaze data to a coordinate system relative to the eye tracker and the recorded field of view. However, most of the time the researcher is interested in mapping gazing data onto selected objects or AOIs, especially when the aim is to combine or compare the gazing behavior of multiple subjects. This processes, despite modern image recognition software, often require intensive and time-consuming human intervention, as the position, size, and orientation of the object or AOI continuously change, caused by the changing field of view of the subject.

A very special group of test persons are babies and infants, because they behave differently compared to reasonable and prosaic adults. Babies have different goals than adults and it is not easy to explain a test situation to them and make them do what the experimenter wants. Babies move more than adults and

it is difficult to keep their attention on the test. It is also true that the algorithms used to detect eye-movement events have been developed for adults and therefore data gained from babies may be less valid. Nevertheless, eye-tracking techniques have already successfully been used to investigate the development of the human visual system in the first 2 years, showing that it matures during the first year and converges to the adult's abilities, e.g., in terms of perceptual completion, predictive smooth pursuit, and social cognition (Gredebäck, Johnson, & von Hofsten, 2009). "Looking times have been a very productive measure over the past 40 years of research on infant sensation, perception, cognition, and language development" (Aslin, 2007).

A general limitation of the eye-tracking methodology, already discussed earlier in this chapter, is that, although gazing behavior and especially fixations are highly correlated with attention, information in the peripheral field of vision can still be perceived and processed to a certain degree and may potentially influence choice or other behavior (Yokoyama, Sakai, Noguchi, & Kita, 2014). Eye tracking can measure only overt, and not covert, visual attention and this technique cannot distinguish between unconscious or conscious overt visual attention. This means that although a stimulus is gazed at, the attention might be distracted by other tasks or cognitive processes. To minimize or control for these effects careful planning by the researcher and standardized tasks and instructions for the participants are crucial.

Another limitation is in regard to the interpretation of data and the underlying processes of eye movements. Aslin (2007) and Gredebäck et al. (2009) emphasize that it can be difficult to relate data of gazing behavior to underlying processes, because several different mechanisms, which are working at different levels (sensory, motor, perceptual, cognitive, and cortical), are controlling gazing behavior. Participants in eye-tracking tests are not able to provide information as to which of the mechanisms were influencing them in their eye movements. Only elaborated experimental design and combining eye-tracking and other methods will make it possible to investigate the relations between eye movements and underlying processes.

Not a limitation but a challenge is the statistical analysis of eye-tracking data. Yielded data are very rich, because eye-movement data are collected with at least 60 Hz over time, which results into big data volumes to be analyzed. Normally commercial eye trackers provide analysis tools, including statistics to characterize gazing behavior and visual attention regarding defined AOIs, and most of these programs can also export eye-movement data to statistical analysis packages.

6. OUTLOOK

The general improvement of eye-tracking technology and the trend toward miniaturization will allow applications in new fields, and one of these challenging application fields of the future will be the use of eye tracking in real-world

environments. For a long time eye trackers were built into computers and used only in laboratory settings; however, since mobile devices have been developed, it is also possible to use eye trackers in real-world situations like supermarkets, restaurants, or cafés. Such experiments are challenging regarding test design, data acquisition, and analysis. Eye tracking will also be used in virtual or augmented reality test designs. However, it is generally expected that experiments in real-world situations have more ecological validity and more power to predict consumers' behavior in everyday life.

Another future direction of eye-tracking applications might be their use in improving and optimizing questionnaires, survey questions, scales, and sensory methods in general. So an observational method might help to improve introspective methods of self-reports. Only a few applications have been published in this area (Galesic, Tourangeau, Couper, & Conrad, 2008; Lenzner, Kaczmarek, & Galesic, 2011; Redline & Lankford, 2001). Ares, Etchemendy, et al. (2014), for instance, evaluated eye-movement patterns in check-all-that-apply (CATA) questions answered by consumers and they used these insights to improve CATA question design successfully. So they concluded that the eye-tracking approach has “potential to be used with other sensory and consumer science tasks” to optimize methodology and develop best practice.

Although several studies have shown that culture can have a significant effect on gazing behavior (Chua, Boland, & Nisbett, 2005; Dong & Lee, 2008) only a very limited number of studies have investigated cross-cultural aspects in choice situations or the food context. Additionally, individual differences, e.g., different cognitive reflection types (fast and slow thinkers; Frederick, 2005) or cognitive styles (holistic vs. analytical thinkers; Nisbett, Peng, Choi, & Norenzayan, 2001), should also be taken into consideration in future research.

Since it became clear over the past decades of consumer research that single-method measurements have only limited power to explain complex consumer behavior, many methods from various scientific disciplines have been integrated into the toolbox of consumer research. For a long time mainly introspective methods using questionnaires based on self-reports have been used; however, for several years observational techniques have been used more intensively. Observational techniques are not biased to the same amount by cognitive thinking as introspective techniques and therefore might help to further elucidate the formation of consumers' experience and behavior. Observational techniques to measure gaze behavior as an expression form of visual attention have been tested in the past decades of consumer research and it has become clear that eye tracking also needs cross-linking with several other methods of consumer research. Therefore, we consider that one of the future directions in gaze research will be the integration of eye-tracking data with other physiological and psychological reactions like facial reactions, respiration characteristics, reactions of the autonomous nervous system and the cardiovascular system, behavior in sensory

testing, or brain activity measures. A complex behavior of human beings such as eating and drinking can be explained only by a complex methodology that does not rely on one or two measured aspects. So obviously this complex object of investigation demands a complex methodology as well, and eye tracking as a method to describe eye movements and visual attention can play an important role in it.

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Part IV

Designing Studies for Specific Populations

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Chapter 13

New Developments in Sensory and Consumer Research With Children

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1. INTRODUCTION

Children and adolescents are increasingly recognized as a large market opportunity for food companies, in terms of absolute size, spending power, and purchasing influence (Oates, Blades, Gunter, & Don, 2003).

Recent developments in marketing opportunities have in part contributed to children’s higher freedom in food and beverage selection and purchase. In fact, in the past few years the technology for advertising has changed, with new and rapidly expanding forms of low-cost media (e.g., digital television, online marketing, mobile and smartphones, and social networking) becoming available to larger numbers of children (WHO, 2013). Unfortunately, the majority of the food and beverage products advertised are soft drinks, sweetened breakfast cereals, biscuits, confectionery, snack foods, ready-to-eat meals, and fast food/quick service outlets, which are rich in fat, sugar, and salt (Kelly et al., 2010), thus resulting in a higher demand for unhealthy food.

Although it is reported that school-aged—and even younger—children have a good understanding of healthy and unhealthy food (Ares et al., 2016; Nguyen, 2007; Tatlow-Golden, Henness, Dean, & Hollywood, 2013; Varela & Salvador, 2014), it is well known that children choose what to eat based on hedonism. In fact, young consumers regard palatability and sensory properties of food products, such as taste, smell, texture, and appearance, as extremely important for their food choices (Pagliarini, Gabbiadini, & Ratti, 2005; Taylor, Evers, & McKenna, 2005). More importantly, reduced liking is reported as one of the key factors involved in the rejection of healthy foods such as fruits, vegetables, fish, and fiber-enriched products (Dovey et al., 2012; Laureati, Cattaneo, Bergamaschi, Proserpio, & Pagliarini, 2016; Zeinstra, Koelen, Kok, & de Graaf, 2010). Therefore, one of the challenges of the food industry is developing food products that meet children’s sensory expectations and liking.

In the past few decades, the development of children’s food products has been often carried out by applying sensory and consumer tests involving adults. This malpractice has been usually justified by children’s inability to perform some sensory tests that are commonly used in food product development (mainly descriptive tests). However, developing foods and beverages targeted to children requires their input because their food perception, expectation, and liking differ from those of adults. It is well documented that children prefer intensively sweet products, dislike bitter tastes, and choose to eat more of their favorite

foods (Nguyen, Girgis, & Robinson, 2015). This pattern contrasts with that of adults, who show more variability in their taste and texture preferences as well as food intake (Drewnowski, Mennella, Johnson, & Bellisle, 2012; Lukasewycz & Mennella, 2012; Zeinstra et al., 2010). Therefore, it is impossible to predict children's food preference and selection without considering actual information from the intended target group.

Understanding children's food preference and behavior has important implications for their health. It is estimated that 41 million children under the age of 5 years in both developed and underdeveloped countries were overweight or obese in 2014 (UNICEF/WHO/World Bank, 2015). Food consumption undoubtedly plays a crucial role in the development of obesity and it strictly depends on individual food perception and preference. The promotion of potentially unhealthy food and beverage products is also widely recognized as a significant risk factor for child obesity and for the development of diet-related noncommunicable diseases. As a result, a series of policy responses have emerged and suggested that governments should work with consumer groups and the private sector to develop appropriate approaches to deal with the marketing of food to children (WHO, 2013). In this context, sensory and consumer research seems relevant for the design of public policies to promote healthier eating patterns and improve the health status of children.

Starting from an overview of the classical methods (i.e., paired comparison, ranking, and rating scales) used to investigate young consumers' perception and liking, this chapter addresses the latest developments in sensory and consumer research with children. New approaches to existing methods (e.g., observational studies), adaptation of methods from other research areas (e.g., sorting and projective techniques, implicit memory paradigms), as well as new methodologies that have been adapted to children (e.g., the check-all-that-apply method) are presented, providing the relevant theory briefly and then focusing on their application, critically discussing the usefulness and drawbacks of each approach. Finally, because children present large cognitive and skills differences even within a specific age group (ASTM, 2013), attention is also devoted to the analysis of the factors that play major roles in determining the appropriateness of approaches to consumer studies with children according to their age.

2. CONSUMER RESEARCH WITH CHILDREN: CLASSICAL METHODOLOGICAL APPROACHES

The methods that are traditionally used in consumer testing with children to measure food liking and preferences (e.g., paired comparison test, ranking, hedonic scales) have been largely studied, and their application to the young consumer is well established (ASTM, 2013; Guinard, 2001; Laureati, Pagliarini, Gallina Toschi, & Monteleone, 2015; Popper & Kroll, 2005). This section is devised

only to provide a brief overview of the classical methods used in sensory and consumer testing with children.

The paired comparison test is the easiest way to get insights into children's preferences because it does not require scaling and is very intuitive. It consists in providing pairs of samples to children and asking them to indicate the preferred one or the one they perceive as more intense for a sensory quality (e.g., sweet taste). A number of empirical studies suggest that this method can be performed reliably as a hedonic task (Cordelle, Piper, & Schlich, 2005; Léon, Couronne, Marcuz, & Köster, 1999; Liem, Mars, & de Graaf, 2004) even with children ages 2–3 years (Kimmel, Sigman-Grant, & Guinard, 1994), whereas starting from 4–5 years it can be used also as a discriminant task (Laureati & Pagliarini, 2013; Liem et al., 2004). Care must be taken in choosing an appropriate number of pairs to keep the task as easy as possible for the children. Up to three pairs can be used with children as young as 2–3 years (Kimmel et al., 1994), whereas with older children pairs can be increased up to 9 (Laureati et al., 2008) or even 10 (Léon et al., 1999).

The ranking method requires samples to be ordered according to increasing or decreasing preference or intensity of a sensory descriptor. When measuring children's preferences, the variant of ranking by elimination is often used, which consists in tasting a series of samples and indicating the most preferred one. Thereafter, children taste the remaining samples again and indicate which they prefer the most until a complete ranking order of preference is established. Because this procedure may require tasting several samples (usually up to six, depending on the product), which implies good memorization skills and sometimes the risk of fatiguing effects, it is recommended for children starting from 4–5 years of age as both hedonic and discrimination tasks (Kimmel et al., 1994; Laureati et al., 2016; Liem et al., 2004).

The 3-point hedonic facial scale is not found very often in empirical studies (Poelman & Delahunty, 2011; Rollins, Loken, & Birch, 2010), probably because, despite being simple, it does not provide much discrimination (Lakkakula, Geaghan, Zanovec, Pierce, & Tuuri, 2010). Five- and 7-point hedonic facial scales are the most popular approaches to measure food liking among children. Evidence of the appropriateness of these scales has been provided in a number of studies demonstrating children's ability to discriminate samples according to liking or an *a priori* modified sensory property (Donadini, Fumi, Vanoni, & Porretta, 2012; Laureati et al., 2016; Laureati, Pagliarini, Mojet, & Köster, 2011; Laureati & Pagliarini, 2013; Pagliarini et al., 2005). Moreover, the predictive validity of the 7-point smiley scale has been established even with children as young as 4–5 years (Caporale, Policastro, Tuorila, & Monteleone, 2009).

There are also examples in the literature of the use of more complex hedonic scales with children, such as the 9-point hedonic facial scale (Moskowitz, 2002) and linear unstructured scale (Cordelle et al., 2005). However, in this last example, the linear scale has been modified to have faces under the extreme anchors to help children to better understand the scale.

To sum up, all classical methods, even the more sophisticated ones, may be successfully used with children. However, the fact that almost all child age groups generally understand classical methods does not mean that all methods perform equally well. In this sense, it is recommended to use very simple methods such as the paired comparison test when children are very young (2–3 years old), whereas, when age increases, hedonic scales (5-, 7-, or 9-point or even unstructured scales) may provide more discrimination among samples.

3. CONSUMER RESEARCH WITH CHILDREN: NEW METHODOLOGICAL APPROACHES

3.1 Sorting and Projective Mapping Techniques

The way we group items together or categorize them determines how we learn about the relationships between objects and how we generalize these relationships to novel items (Mareschal & Quinn, 2001). Categorization abilities mainly develop during early childhood, when children encounter many new stimuli. Without these abilities, children would have to learn to respond anew to each novel stimulus (Lafraire, Rioux, Roque, Giboreau, & Picard, 2016).

Sorting has been traditionally used in childhood psychology, anthropology, and sociology studies to investigate conceptual development, but it has also been used in other research areas, such as food science for product development or social science with the purpose of food education. The procedure consists in measuring the degree of similarity/dissimilarity between samples by sorting them into groups considering that, if two samples are perceived as similar, they should be placed in the same group, whereas if two samples are different they should be placed in different groups (Varela & Ares, 2012).

The increased interest toward food categorization among children is justified by the fact that sorting methods are easy to understand and child-friendly, as many games are based on sorting of shapes and colors, so it is a procedure familiar to children (Varela & Salvador, 2014).

There is evidence that children are able to use several category systems to classify things and also food, among which are thematic, script, and taxonomic categories (Nguyen & Murphy, 2003). Thematic categories group objects that are associated or have a complementary relationship (e.g., breakfast cereals and a bowl). Script categories are formed when items play the same role in a specific situation (e.g., cereals and milk are both breakfast foods). Taxonomic categories usually are organized into hierarchies of increasingly abstract categories that share similar properties (e.g., cereals and carbohydrates or milk and dairy products).

Early research has shown that preschool children often group objects using thematic or script categories, probably because the external relations involved in these categories, being based on experienced events rather than abstractions, are easier for children to identify than the similarities underlying taxonomic

categories (Markman, 1989). However, more recently it has been shown that by the age of 4 years, children may use multiple categorization systems and are even able to cross-classify food items, namely to categorize the same food using different category systems (e.g., taxonomic and script categories), indicating a certain degree of flexibility in their conceptual skills (Nguyen & Murphy, 2003).

An overview of the significant studies carried out on children's ability to categorize food items is given in Table 13.1.

Using a sorting procedure, Bovet, Vauclair, and Blaye (2005) observed that at age 3, the majority of children successfully sorted pictures of food and toys into different boxes, thus showing a basic ability for conceptual categorization in the food domain. Similarly, in a more recent study, Lafraire et al. (2016) showed that children are able to discriminate between food and nonfood items quite efficiently, even with extremely brief stimulus presentation times (i.e., 80 ms), indicating that rapid categorization paradigms, which have the advantage of encouraging subjects to make rapid intrinsic decisions, can be successfully applied to very young children.

Nguyen (2007) found that children ages 3, 4, and 7 years were able to categorize pictures of foods accurately as “junky” or “healthy,” concluding that their classifications corresponded to expert classifications to some degree by age 3 years, and that children would start understanding the reasoning behind these classifications by the age of 4 years. Nevertheless, in our opinion children's perception of nutritional aspects cannot be isolated from their hedonic appreciation, their actual food choice being influenced by multiple parameters. In this sense, Tatlow-Golden et al. (2013) found that young children (3–5 years) had very high levels of ability to identify healthy foods as important for health, but considerably less ability to reject unhealthy items, showing that not only nutritional knowledge but also hedonics would be a determinant of their behavior.

Interestingly, Varela and Salvador (2014) used a more complex approach (i.e., structured sorting), which can be assimilated to a sort of projective mapping technique.

Projective mapping or Napping and derived techniques are simple user-friendly procedures that have gained popularity within the field of sensory and consumer science. These are holistic methods, meaning that products are considered as a whole, allowing naïve subjects to map products on a bidimensional space based on similarities/differences (Risvik, McEvan, Colwill, Rogers, & Lyon, 1994). More specifically, Napping consists of providing a set of products to subjects, who are asked to position them on a large sheet of paper or a screen (tablecloth) according to their own criteria (Pagès, 2005). As such, products placed in close proximity to one another are perceived as similar, while products placed far from one another are perceived as different.

These methods have been applied with adults for several purposes, such as cross-cultural studies (Laureati, Pagliarini, Bassoli, & Borgonovo, 2014) or in comparison with descriptive methods (Holler Mielby, Hopfer, Jensen, Thybo,

TABLE 13.1 Overview of Significant Studies on Food Categorization in Children

Children's Age (Years)	Food Stimuli	Main Results	Reference
3, 4, 7	102 pictures of familiar foods (arranged in 34 triads and, only for 3-year-olds, in 24 triads)	By age 4 years, children understand taxonomic, script, and evaluative categories and are able to cross-classify food items; children age 3 years use both taxonomic and script categories	Nguyen and Murphy (2003)
3, 4, 7	70 pictures of familiar foods	Children's ability to accurately classify food as healthy/ junky improved with age, but it was good starting at the age of 3 years; 7-year-olds and to some extent 4-year-olds were able to explain their evaluative classifications with relevant justifications	Nguyen (2007)
3–5	16 pictures of food or drink items	Children have very high levels of ability to identify healthy foods, but considerably less ability to reject unhealthy items	Tatlow-Golden et al. (2013)
5, 7, 9	12 pictures of foods	The three age cohorts were very similar; they were able to group the products taking into account both healthiness and hedonic perception	Varela and Salvador (2014)
3–4.5	40 pictures (20 food and 20 nonfood items)	Rapid categorization paradigms can be successfully applied to young children; categorization ability increased with age, while response times decreased	Lafraire et al. (2016)
5–11	10 triplets of food pictures (implicit pairing task); 49 food pictures (explicit forced-choice categorization task)	Hedonic categorization prevails in the implicit task, whereas nutritional categorization prevails in the explicit task	Monnery-Patris et al. (2016)

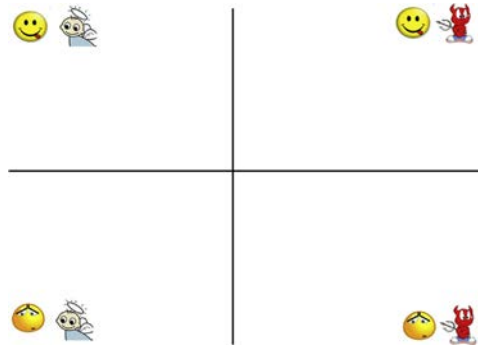


FIGURE 13.1 Structured sorting ballot. (Taken from Varela, P., & Salvador, A. (2014). *Structured sorting using pictures as a way to study nutritional and hedonic perception in children*. Food Quality and Preference, 37, 27–34.)

& Heymann, 2014). In its simplest form, it is a nonverbal method based on perceptual distances among products, which can be advantageous for children, especially the youngest, who may encounter difficulties in developing a sensory lexicon (Laureati, Pagliarini, et al., 2015).

In the study by Varela and Salvador (2014), it was investigated whether children aged 5, 7, and 9 years were able to categorize food items based on both the healthiness and the hedonic dimensions by providing them with pictures representing various healthy and unhealthy foods and asking them to allocate each picture on an A4 sheet separated into four equal quadrants, labeled with two symbols each, to convey four groups (healthy/liked, healthy/disliked, unhealthy/liked, unhealthy/disliked). The symbols were a “yummy face” (a smiley figure with the tongue out), a “yucky face” (smiley with a “do not like” face), a devil (meaning “bad for you”), and an angel (meaning “good for you”) to represent their liking and perception of healthiness (Fig. 13.1). Thus, the approach appeared to the children as a game, likely to increase their degree of involvement and attention span. The results for the three age groups were very similar, and children were able to group products taking into account both healthiness and hedonic perception as instructed, suggesting that children as young as 5 years can manage to understand tasks such as structured sorting and projective mapping. However, despite the apparent simplicity of the method, caution should be taken to explain how to use the entire bidimensional space to the children, for instance, using different geometrical shapes and/or colors. Moreover, projective mapping and Napping have been reported to work better when at least 8–12 samples are tested simultaneously, which can be tricky for children, who may develop sensory fatigue and boredom. In this sense, in the Varela and Salvador study, food pictures were used, but it would be interesting to see whether using real food can be feasible with children.

Another approach is the one by Monnery-Patris, Marty, Bayer, Nicklaus, and Chambaron (2016), who used both an implicit pairing and an explicit

forced-choice categorization task to test the ability of primary school children (5–11 years) to associate different foods according to hedonic and nutritional dimensions. The two approaches provided a divergent outcome, with the implicit paradigm revealing a predominance of hedonic associations and the explicit paradigm showing a prevalence of nutrition-based associations.

Children involved in the aforementioned studies were in general very young, starting from the age of 3, but in some cases arriving at 11 years. When the age range was quite broad, thus involving children with different cognitive and motor skills, the methodological approach was slightly modified to meet the needs of the youngest children, for instance, by reducing the number of stimuli to be tested (Nguyen & Murphy, 2003), or allowing more time for execution of the task (Varela & Salvador, 2014), or again by developing story-based methods to keep attention and involvement high (Nguyen & Murphy, 2003; Tatlow-Golden et al., 2013). The tasks were always self-administered by the children, who were tested in groups or individually, independent of age. In most cases, a warm-up phase was found to be appropriate to familiarize the children with the procedure. A further important consideration is that in all the aforementioned papers the foods were presented as visual stimuli, thus simplifying the understanding of the task and categorization of items. In this sense, we believe it would be interesting to include real food in the sorting tasks, as the interaction between the healthiness and the actual hedonic response could be more complex than that highlighted by the expected liking elicited by a picture.

To sum up, the findings of the most recent studies on children's food categorization ability indicate that young consumers are precocious in dealing with food categories and that if age-appropriate protocols are used they can even correctly categorize food items based on multiple dimensions. Although further research is needed to better understand the mechanisms underlying food association and categorization in children, we believe these findings have important implications from a sociological and educational point of view, because they suggest that it is important to teach children about healthy and unhealthy foods in the preschool years. In addition, because categorization abilities are useful to children, especially when they encounter new stimuli, investigating how they conceptually represent and organize the set of information about food nutrition may be important to guide them toward a more varied diet.

3.2 Sensory Characterization of Food Products With Children

3.2.1 Issues and Early Research in "Sensory Characterization of Food Products by Children"

Identifying the sensory properties that drive children's likes and dislikes is an old and important challenge for the food industry. To develop food products that meet children's specific needs, it is extremely important to use the appropriate

methodological approach, which enables the identification of the desirable and undesirable properties and, thus, the optimization of products tailored for young consumers.

Descriptive methods are helpful in establishing the key sensory properties that drive consumers' liking. However, because of their complexity, these methods are usually not recommended for young consumers (Laureati, Pagliarini, et al., 2015). Children would indeed need to be trained to be objective and able to use rating scales correctly. Moreover, they can focus on only a few aspects of a product and lack concentration and attention. Therefore, as far as descriptive methods exist, they have been used almost exclusively with adults. This is understandable, but it would imply that food preferences of both adults and children should be influenced by the same sensory aspects, which is very unlikely.

In fact, there is a large body of evidence showing that children differ in several ways from adults in sensory perception. For instance, the sense of taste is still developing by midchildhood (Segovia, Hutchinson, Laing, & Jinks, 2002; Stein, Laing, & Hutchinson, 1994). Moreover, children have weaker jaw muscles (Braun et al., 1996) and fewer teeth than adults (20 vs. 32) (Tortora & Grabowski, 1996). These factors could result in different perception of texture and slower or reduced flavor release (Rose, Laing, & Hutchinson, 2004) with consequent important differences in liking.

There are very few examples in the literature of the use of sensory profiling with children. Sune, Lacroix, and de Kermadec (2002) compared a panel of 9–11 years old children with a trained panel of adults in their ability to generate and rate sensory descriptors of chocolate bars. They found that the children were able to generate as many descriptors as the adults, with visual attributes representing almost half of the answers for both groups. Despite children being less accurate in their gustatory description, their visual description seemed more analytical. Moreover, the children's evaluation of the intensity of the descriptors was highly related to that of the adults, especially for appearance and texture, whereas for flavor attributes the relation was weak.

Rose et al. (2004) also reported that separate groups of children aged 6–7 and 8–11 years generated more descriptors for appearance of meat products than for any other modality. This is probably reflected by the fact that starting from an early age, the child is accustomed to describe what he or she can see, with the result that this vocabulary becomes accurate, relevant, and better defined.

Although the studies by Sune et al. (2002) and Rose et al. (2004) demonstrated that children can generate descriptors that are appropriate for describing a food product, the procedures used were lengthy. Long procedures can translate into lack of attention by the child, thus reducing the reliability of the measurement. In addition, in both studies, food products with clearly distinguishable sensory profiles were chosen to facilitate the task for the children. This is not always representative of a food product development problem-solving situation, which often requires that subtle differences be detected and described.

Therefore, it seems that finding a suitable and reliable procedure to identify the sensory properties of food tailored for children is still one of the biggest challenges for food companies and sensory and consumer research scientists. In this context, great support could be provided by using rapid sensory techniques that have been proposed as an alternative approach to classical sensory descriptive analysis.

3.2.2 Use of Alternative Techniques to Gain Insight into Sensory Profiling by Children

Sensory descriptive analysis is one of the most powerful, sophisticated, and widely used techniques in sensory science. It enables obtaining both qualitative and quantitative descriptions of the sensory properties that characterize a food or a beverage. Despite allowing the acquisition of very robust and reliable results, it is usually extremely time consuming. As a result, several novel techniques have been proposed as alternative approaches to classical sensory characterization of food products. These methodologies can be used with semitrained assessors or even with consumers, thus, they have the great advantage of being simple, fast, and less time consuming and provide sensory maps that are very close to those obtained through classical descriptive analysis (Varela & Ares, 2012). The first techniques that were developed with this purpose date back to the 1980s and are free-choice profiling (Williams & Arnold, 1985) and repertory grid methods (Thomson & McEwan, 1988). While there are few and not very recent examples in the literature of the repertory grid method with children in the food domain (Baxter, Jack, & Schroder, 1998; Sune et al., 2002), to the knowledge of the present authors, no studies have been conducted using free-choice profiling with children as of this writing.

More recently, other rapid sensory techniques have been developed, such as flash profiling, projective mapping or Napping, check-all-that-apply (CATA) questions, polarized sensory positioning, and preferred attribute elicitation method (Varela & Ares, 2012). Most of these approaches are already validated with adults but examples of applications with children exist only for projective mapping/Napping and CATA questions.

The previously cited study by Varela and Salvador (2014) is a good example of the use of projective mapping/Napping with children. The aim of this study was not to provide a sensory characterization of food products by children but rather to test their ability to categorize food items according to both healthiness and hedonic dimensions. However, children's ability to complete a projective mapping task was clearly demonstrated, suggesting that the approach could be adapted to ask children to position a series of samples according to some key sensory properties, thus obtaining a sensory map of the attributes that characterize the products based on children's perception.

Unfortunately, to the knowledge of the present authors, there are no other studies on this topic as of this writing, and further research is needed to verify

whether projective mapping and Napping techniques can be used with children as an alternative approach to gain insights into the sensory properties that drive likes and dislikes of the young consumer.

3.2.2.1 Check-All-That-Apply Method With Children

Another rapid sensory technique that has been applied involving children is the CATA questions approach. This method is used to define which sensory attributes consumers perceive in food products. It consists of two phases: a first step in which a list of words or phrases is generated and a second step in which subjects choose, from the list, all the expressions they consider suitable to describe a product. In such a way, subjects are not forced to evaluate all attributes on a scale (Ares & Jaeger, 2015). The list in the CATA question method could be related exclusively to the sensory characteristics of the product or also include terms related to appropriate contexts and emotions.

The efficiency of the CATA questions in evaluating adults' sensory perception of a food product has been confirmed by various studies (Ares, Deliza, Barreiro, Gimenez, & Gambaro, 2010; Dooley, Lee, & Meullenet, 2010; Perrin et al., 2008). In addition, this approach has been reported to be intuitive and consumer-friendly and to minimize the subject's cognitive processing (Ng, Chaya, & Hort, 2013); all these aspects make CATA questions a good candidate method to be used with children.

This approach has been applied successfully with 8- to 13-year-old children to obtain emotion profiles of food (De Pelsmaecker, Schouteten, & Gellynck, 2013), but it has never been tested as an alternative to descriptive methods in food product development. In this sense, our experience suggests that the CATA questions method has potential in sensory and consumer testing with children. We have conducted a study (Laureati et al., 2017) in which we wanted to test the suitability of the CATA method to obtain a sensory description by children aged 8–11 years of apple purees varying in appearance (either yellow or red) and texture (from smooth to particulate). The selection of the list of sensory attributes was performed directly with a small group of 10 children. The selection of words or phrases included in the CATA questions is one of the main challenges of the methodology (Varela & Ares, 2012), especially if children are involved in the task. In fact, children might understand some terms different from adults or not understand some CATA terms at all. Therefore, the phrasing of the options in CATA for children should be carefully thought through. Moreover, sensory attributes should be generated and pilot tested preferably with children, as abstraction power and metaphorical thinking are limited at young ages (Varela et al., 2016). Suitable ways for children to elicit attributes are open-ended questions or focus groups. In our study, the elicitation of the terms was carried out by means of a free listing questionnaire followed by an open discussion to develop the lexicon, which included 12 attributes: two for appearance (red color and brownish color), three for taste/flavor (fruity flavor,

sweet taste, and sour taste), and seven for texture (sticky, doughy, gluey, floury, granular, sandy, and crunchy).

A separate, larger group of 62 children (8–11 years of age) used these terms to describe six apple purees. They were presented with the list of descriptors and asked whether they knew the meaning of each word (if not, a brief explanation with examples was given). After that, they tasted the samples one at a time and selected all the words suitable for describing that sample. Overall liking was also investigated using a 7-point smiley scale.

The frequency table of terms checked by the children is reported in [Table 13.2](#). The children were able to distinguish the samples correctly according to their appearance and texture attributes, except for the gluey and sticky attributes. Taste and flavor attributes were not different among the samples, which makes sense, as the apple purees were manipulated to vary only for appearance and texture.

CATA question results can be easily analyzed together with hedonic data to obtain a map showing the drivers of liking of the products ([Ares, Dauber, Fernández, Giménez, & Varela, 2014](#); [Meyners, Castura, & Carr, 2013](#)), which is very useful information for food companies that are developing products targeted at children. This approach seemed to work well with our case study on apple purees.

Although our data are preliminary, we believe that this technique could be useful for food products research and development to understand children's drivers of liking and to obtain effective input for product optimization, ensuring their success with this specific target of consumers. Indeed, the CATA method has the important advantage of not requiring rating the intensity of the attributes, thus it minimizes the time for the respondent and it is easy to understand ([Ng et al., 2013](#)).

Because this method requires good verbal skills in the first phase of terms elicitation as well as in the second phase, its application should be limited to children of 8 years or older, because at this age vocabulary skills and self-expression improve and are sufficient for most self-administered tasks.

However, it would be interesting to investigate whether this approach is suitable for younger children (ages 6–8 years). In this case, a very simple lexicon should be used (e.g., salty taste/no salty taste) and adult assistance is advised ([Varela et al., 2016](#)).

3.3 Implicit Paradigms to Assess Incidental Learning and Food Memory

3.3.1 Classification of Food Memory

Before discussing incidental learning and food memory assessment in children, it might be of help, to clarify how food memory works and how it is classified.

TABLE 13.2 Number of Sensory Attributes Used by Children (n = 62) to Describe Apple Purees Varied in Color (Yellow-Brownish and Red) and Texture (Apple Fiber Added as Large Pieces, Small Pieces or Powder) Using the CATA Method

Sensory Attribute	Frequency of Mention (%)					
	Yellow-Brownish Apple Purees			Red Apple Purees		
	Large Pieces	Small Pieces	Powder	Large Pieces	Small Pieces	Powder
Red color***	0.0	0.0	0.0	98.4	98.4	100.0
Brownish color***	54.8	54.8	61.3	0.0	0.0	0.0
Fruity flavor	66.1	67.7	62.9	61.3	69.4	58.1
Sweet taste	66.1	59.7	72.6	69.4	66.1	79.0
Sour taste	21.0	19.4	12.9	16.1	29.0	22.6
Sticky	14.5	22.6	21.0	17.7	12.9	14.5
Doughy*	24.2	29.0	37.1	24.2	17.7	25.8
Gluey	11.3	9.7	8.1	8.1	9.7	8.1
Floury*	8.1	11.3	16.1	12.9	14.5	21.0
Granular***	59.7	50.0	17.7	59.7	54.8	12.9
Sandy*	19.4	16.1	30.6	9.7	17.7	32.3
Crunchy***	21.0	14.5	3.2	25.8	14.5	1.6

* $P < .05$; *** $P < .001$.

Taken from Laureati, M., Cattaneo, C., Lavelli, V., Bergamaschi, V., Riso, P., Pagliarini, E. (2017). Application of the Check-All-That-Apply method (CATA) to get insights on children's drivers of liking of fibre-enriched apple purees. *Journal of Sensory Studies*, 32(2), e12253.

Memory is defined as the ability to store, retain, and subsequently retrieve information. Three main stages characterize memory mechanisms (Baddeley, 1997):

1. The acquisition or *encoding phase*, usually termed the learning phase, is responsible for the registration of the information.
2. The *retention phase* is responsible for storing the information (this is the stage to which the term memory itself most frequently refers).
3. The *retrieval phase* is related to the recall of the stored information.

A basic and generally accepted classification of memory is based on the duration of memory retention and identifies two distinct types of memory (Tulving & Craik, 2000):

1. *short-term memory*, in which the information is available for a certain period of time, but is not retained indefinitely (normally from a few seconds to a minute);
2. *long-term memory*, which can store much larger quantities of information for potentially unlimited duration (sometimes a whole life span).

According to textbooks (Baddeley, 1997; Tulving & Craik, 2000), a further classification divides long-term memory into *declarative* (or *explicit*) and *nondeclarative* (or *implicit*) memory (Fig. 13.2). Declarative memory requires conscious recollection of the information. It is sometimes called explicit memory, because it consists of information that is explicitly stored and retrieved (e.g., making an effort to remember a telephone number). In contrast, nondeclarative memory is characterized by unintentional learning (e.g., driving a car), or learning without awareness (incidental learning) (Larsson, 2002).

That said, how then can food memory be classified? Let us think about a very common action in our everyday life, i.e., food consumption. When eating a pizza or drinking coffee, it is extremely unusual to consciously decide

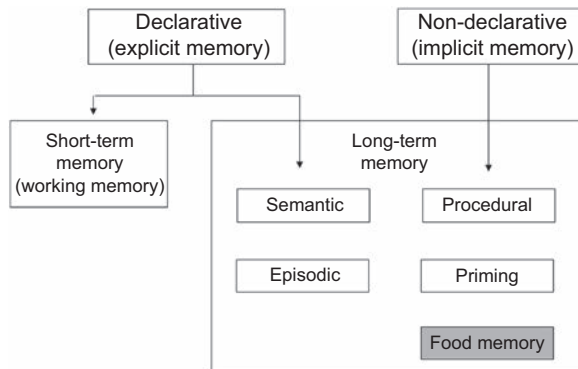


FIGURE 13.2 Schematic classification of human memory.

“I have to remember this food” (Laureati et al., 2008). Actually, much of our knowledge about food is acquired incidentally, without any explicit attention or learning, and stored implicitly (Mojet & Köster, 2005). Moreover, many studies on memory of taste, aroma, and texture of food have evidenced the longevity of food memory (Morin-Audebrand et al., 2012). Food aversions are also a remarkable example of food memory resistance to forgetting. In fact, it is even enough that the consumption of a food provoked a disease only once (e.g., nausea or vomiting) to develop a strong and long-lasting aversion for such a food (Sulmont-Rossé, Issanchou, & Köster, 2003). Although food aversions are considered to be more resistant to forgetting than food preferences, some examples of longevity of the latter are available in the literature. Haller, Rummel, Henneberg, Pollmer, and Köster (1999) indicated that people (mean age 30 years) who had been bottle-fed with vanilla-flavored milk as a newborn, later in life showed a preference for a ketchup with added vanillin, whereas people who were breast-fed clearly preferred ketchup without it, thus suggesting that early exposure has very long-lasting effects. Even in a much simpler case, when we are eating our favorite brand of biscuits and we realize that something in its formulation has changed, we are very disappointed about that and are less likely to buy it again.

Based on this evidence, it can be argued that food memory can be classified to a very large extent as a kind of long-term, nondeclarative memory (Fig. 13.2).

3.3.2 *The Role of Memory in the Context of Food Consumption and Application of Implicit Paradigms to Children*

One of the main functions of food memory is to recall previous experiences associated with food. Accordingly, food memory influences the sensory and hedonic perception of a food during its consumption through the generation of expectations and the expression of cognitive associations. The resulting sensory image is added to memory and may in turn influence subsequent food experiences (Morin Audebrand et al., 2009).

Although the implicit nature of food memory is evident, most of the studies available on the memory of sensory stimuli deal with conscious and intentional mechanisms of learning, thus omitting the incidental component of such processes and the understanding of food memory under ecological conditions (Issanchou, Valentin, Sulmont, Degel, & Köster, 2002). To overcome this limit, an implicit paradigm has been developed (Mojet & Köster, 2002) and successfully applied to children (Laureati et al., 2008; Laureati & Pagliarini, 2013; Laureati et al., 2011). The paradigm consists of inviting people (including children) under a false pretense (e.g., study of liking for children or hunger feelings for adults) to consume one or more target foods, which are embedded in a real eating situation. To ensure incidental learning of the target items, memory is never mentioned. After an interval phase (hours, days or weeks), children are invited again to take part in an experiment in which they are asked to recognize

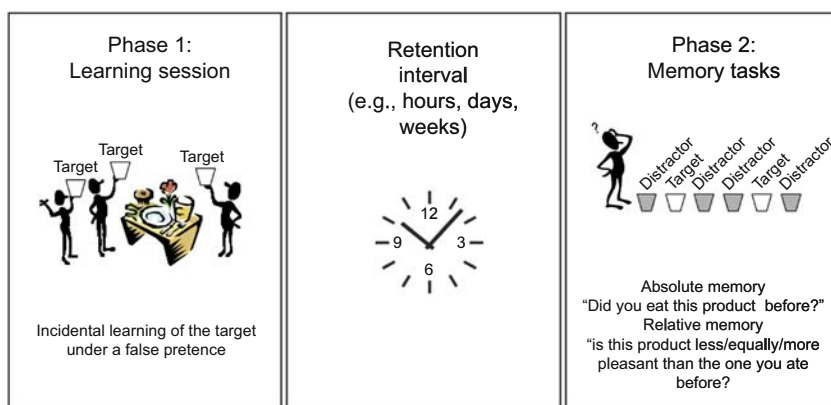


FIGURE 13.3 Representation of the main phases of the implicit paradigm used to study the properties of food memory. (Modified from Morin-Audebrand, L., Mojet, J., Köster, E.P., Møller, P., Issanchou, S., & Sulmont-Rossé, C. (2007). *Memory for food: A comparison of different studies*. Presentation given at the 7th Pangborn Sensory Science Symposium, 12th–16th August, Minneapolis, USA.)

the target food eaten previously among a series of distracters, i.e., products that slightly deviate from the target in terms of sensory properties. Memory is tested in two ways, as absolute memory by asking the holistic question “Is the present food the same as the one you ate yesterday/one week ago?” or as relative memory, in this case memory is evaluated in relation to a specific sensory property of the food, e.g., “Is the present food more pleasant/sweet/thick than the one you ate yesterday/one week ago?” (Fig. 13.3).

This paradigm might seem somewhat complicated to be used with children, first, because of the nature of the products to be tasted, consisting of several distracters, which have only subtle differences with the target, and second, because the questions asked in both memory tasks (absolute and relative) might be tricky. Despite this, the paradigm has been shown to work well with children.

For instance, Laureati et al. (2008) evaluated incidental learning and memory for liking of custard desserts varied in three sensory modalities (i.e., taste, flavor, and texture) in children aged 9–11 years and in a control group of adults (18–45 years of age). During the incidental learning phase, the children received a target custard dessert along with other foods, which were consumed at school as a midmorning snack. The day after, the same children were confronted with three samples identical to the target and with the nine distracters. Within each modality, the distracters were 1.5 JND lower or 1.5 and 2.5 JND higher than the target (the JND, just noticeable difference, was used as a common unit of variation). Children were unexpectedly asked to perform an “absolute memory” and a “relative memory” test. It was found that children had a good recall of the custard dessert eaten the day before (i.e., target) in terms of liking, as in the relative memory task they judged the target as equally pleasant compared to the one eaten the previous

day. Conversely, the distracters with increased concentration of sugar and cherry aroma were remembered as less pleasant than the target. Moreover, no differences in the way food is remembered were found between children and adults, emphasizing that children understood the task and were able to precisely store and retrieve information about the food they eat.

Accordingly, [Laureati et al. \(2011\)](#) demonstrated that the same paradigm can be successfully used with even younger children (ages 7–10 years). In this case, the task was easier compared to the one reported above, because the distracters differed slightly from the target only for sweetness and the number of products presented during the memory task was reduced to four (two targets and two distracters).

Evidence of children's reliability in performing memory tasks was also provided by [Laureati and Pagliarini \(2013\)](#), who showed that children were able to correctly recognize distracters varying in levels of sweetness from memory, hedonic, and perceptive points of view. Interestingly, they also found that children's memory was better under incidental than under intentional conditions, thus suggesting that explicit paradigms, being less ecologically valid, should be cautiously considered when applied for studying food learning and memory ([Laureati, Pagliarini, et al., 2015](#)).

Although the number of studies on children's incidental learning and memory for food stimuli is still reduced, findings suggest that, starting from 7 years, children can reliably perform such kinds of tasks. Until now, only memory for liking has been assessed but it might be interesting to verify whether the young consumer is able to perform tasks in which memory for sensory properties such as sweet taste or texture is investigated. This would certainly benefit product development research in which implicit measures are often underestimated and neglected, despite being more ecologically valid than traditional hedonic methods.

3.4 Measurement of Food-Related Emotions

It is generally accepted that moods and emotions can exert a strong influence on food choice, independent of other factors commonly measured in sensory and consumer science, i.e., liking and wanting ([Köster & Mojet, 2015](#); [Meiselman, 2015](#)).

Emotions and food are intertwined in a mutual relationship: on one hand, emotions can influence food choice and intake, whereas on the other hand eating and drinking can modulate our feelings ([Vidal, Ares, & Jaeger, 2016](#)). Emotional eating and its impact on food intake have been extensively studied in children, especially in relation to eating disorders and obesity development ([Gibson, 2006](#); [Striegel-Moore et al., 1999](#); [Tanofsky-Kraff et al., 2007](#)). Conversely, studying the effect of consuming food on children's feelings has received almost no attention, despite having important implications in food product development and marketing.

The most common approach to investigate the impact of consuming food on people's mood and feelings is measuring explicit emotions using questionnaires and rating scales (King, Meiselman, & Carr, 2010; Ng et al., 2013; Spinelli, Masi, Dinnella, Zoboli, & Monteleone, 2014).

De Pelsmaecker et al. (2013) demonstrated how 8- to 13-year-old children may correctly associate different emotions with different brands of flavored milk. In this study, the children themselves generated a list of 20 emotions taken from previous research with adults (De Smet & Schiffertein, 2008; King et al., 2010) that were subsequently classified as positive, negative, or neutral. To facilitate the task for the children, the authors used the CATA questions method to link the emotions to the samples. It was found that 19 of the 20 emotions discriminated the six brands of milk. Interestingly, children associated positive emotions more frequently with the leader brands than with the less known products, a clear demonstration that they understood the task.

Despite questionnaires being commonly used to obtain emotional profiles by consumers, even children, Köster and Mojet (2015) have highlighted and discussed the drawbacks of explicit measurements based on standardized emotion lexicon and intensity rating scales. To use their own words: "Eating consciously and attentively or explicitly thinking about a food as a source of emotion are very unnatural behaviors ... the attention to suggested words and the necessity to make a choice may severely distort the actual experience" and again "... the necessity of explicit attention is the major handicap with all methods that use verbal material." Thus, they expressed the need in consumer research for methods that spontaneously capture food-related emotions in an ecological context, which is also the opinion of the present authors. Transferring this recommendation to the world of the young consumer may have important advantages. First, as highlighted by Köster and Mojet (2015), implicit measurements may reduce the bias of getting socially desirable answers, which is often reported in consumer testing with children (ASTM, 2013). Second, implicit measures, being mainly nonverbal methods based on observations of people, do not rely on cognitive development, thus overcoming difficulties related to children's short attention span and limited cognitive or language ability.

3.5 Implicit Emotion and Liking Measurement

3.5.1 *Observational Studies*

Examples of implicit measures used with children to investigate emotions and their relation with food consumption are observational techniques, which have gained increasing attention since 2007 in response to the availability of specific software that can either translate facial muscle movements into basic expressions such as happy, sad, angry, surprised, scared, disgusted, and neutral (i.e., face reading) or track gazing behavior (i.e., eye tracking) (Laureati, Pagliarini, et al., 2015). Observational studies in children were introduced

by Steiner and colleagues in the 1970s with the aim of getting insights into newborns' and infants' reactions to food stimuli. His pioneering studies demonstrated that newborns and infants show systematic patterns of facial expressions in response to various basic tastes (Steiner, 1979). For instance, sweet taste elicits facial relaxation, sucking, tongue protrusions, and smiles; sour taste elicits lip pursing; a bitter taste gives rise to head turns, mouth gaping, nose wrinkling, and lowered mouth corners; while a salty taste has a less distinctive pattern.

The use of observational studies to interpret reactivity responses to food has been extended to toddlers (Monnery-Patris et al., 2015) and to school-age children, with some contradictory outcomes and limitations being highlighted.

Soussignan, Schaal, Boulanger, Gaillet, and Jiang (2012) compared orofacial reactivity, liking, wanting, and preference for visual and odor cues related to food and nonfood items in 6- to 11-year-old overweight and normal-weight children. Lip sucking was clearly associated with higher liking for both visual and olfactory food cues. In addition, overweight children displayed a higher frequency of lip sucking when exposed to high-energy-dense food pictures and food odorants than normal-weight children. Interestingly, overweight and normal-weight children did not differ in their liking, wanting, or preference for the food cues, suggesting that facial expressions might be more sensitive than self-reports for predicting overweight/obesity development.

Conversely, Zeinstra, Koelen, Colindres, Kok, and de Graaf (2009) found that facial expressions are suitable to measure dislike, but not to measure various gradients of food acceptance in children ages 5–13 years. Accordingly, De Wijk, Kooijman, Verhoeven, Holthuysen, and de Graaf (2012) compared facial expressions in response to the sight, smell, or taste of liked and disliked food in children (8–10 years of age) and adults, and concluded that facial expressions successfully reflect negative but not positive food preferences.

One of the main reasons that can be put forward to explain the literature discrepancy is that in the Soussignan et al. study facial reactions to visual and olfactory stimuli were tested, whereas in the Zeinstra et al. and DeWijk et al. studies the facial reaction was measured after tasting actual food. Thus, it might well be that the mouth and head made movements while eating disturbed facial expressions. Moreover, it should be considered that usually humans choose to consume the food they like, which may result in neutral or mild and very brief positive reactions that are difficult to distinguish based on facial reaction. Another concern with this type of behavioral measurement is that large variations in expressiveness can be found, with some children being more expressive than others (Zeinstra et al., 2009). Thus, future research should investigate the role played by intersubjectivity and the development of the ability to control and mask facial expressions over childhood.

3.5.2 Eye Tracking

Eye tracking is another behavioral measurement that is increasingly used to study children's gazing behavior and the visual attraction of food. Because empirical studies in adults suggest that attention bias for food could be a risk factor for overeating (Castellanos et al., 2009), research is mainly focused on children's visual responsiveness to healthy versus unhealthy food.

Werthmann et al. (2015) tested whether obese children (mean age 11.9 years) have a higher attention bias for food compared to healthy-weight children of comparable age, but, actually, no differences were found. However, initial orientation bias was related to a reduced weight loss after 6 months in children with obesity, suggesting that automatically directing attention to food cues might facilitate further weight gain in children with obesity. In this sense, eye-tracking paradigms might be useful to investigate the development of self-regulatory skills in children in relation to nutritional status, as Junghans, Hooge, Maas, Evers, and De Ridder (2015) also did in their study in which children (mean age 9.9 years) and adults were compared for self-regulatory capacity to resist food temptations. By measuring visual attention, in terms of gaze direction and duration, to healthy and unhealthy food the study revealed that both children and adults had an initial attentional bias toward unhealthy, attractive food. However, as time elapsed adults shifted their visual attention away from the unhealthy food, whereas children remained focused on the unhealthy food. No information about the children's nutritional status was provided, thus it is difficult to say whether body mass index differences exist in children with self-regulation skills.

Another study assessed the potential moderating role of attentional bias in the effect of advergames promoting energy-dense snacks on children's snack intake and concluded that higher gaze duration and faster latency of initial fixation increased food intake of the advertised snacks (Folkvord, Anschutz, Wiers, & Buijzen, 2015).

Finally, eye tracking has also been used to relate visual attention to healthy and unhealthy food with food and beverage preferences and choice in a group of 102 children and adolescents (age range 8–15 years) (Velasquez & Pasch, 2014). Children who looked longer and more frequently at unhealthy food and beverage items appeared to prefer them and might also choose them. However, this association was not significant after controlling for demographic characteristics.

It would be interesting to extend the field of application of eye-tracking techniques to investigate children's perception of information provided on labels and packaging to identify the factors (e.g., logos or colors) that attract children's attention to the most health-relevant information and possibly find interventions that could be employed by policy makers to guide informed food choices.

In summary, in our opinion eye tracking is certainly an interesting method providing useful information about emotional reactions to food with great potential in sensory and consumer testing with children that has not completely emerged yet. However, it remains a handicap in that it can be applied only to visual stimuli, thus reducing considerably the applicability of the method.

3.5.3 Use of Emoticons and Emojis

An interesting alternative to study emotional responses to food and beverages is the use of emoticons and emojis. Internet and social media represent an opportunity to obtain spontaneous consumer information elicited in real-life situations and are becoming more and more widely available to larger numbers of children (WHO, 2013).

The origin of the term “emoticon” derives from the combination of two English words “emotion” and “icon.” An emoticon is a pictorial representation of a facial expression using punctuation marks, numbers, and letters, usually written to express a person’s feelings or mood, for example, :) for happy and :(for sad (Wikipedia, 2016). Emoji is a Japanese word meaning “picture word,” since in this case graphical characters are used to convey expressions (Vidal et al., 2016).

Both emoticons and emojis are commonly used by consumers of both genders and of all age groups in computer-mediated communications, in social networks, and with smartphones.

Social media have been used in food-related consumer research by Vidal, Ares, Machín, and Jaeger (2015) and Vidal, Ares, and Jaeger (2016), who analyzed tweets about breakfast, lunch, snack, and dinner eating situations to gain insights into consumers’ spontaneous expressions of food-related emotional experiences. They found that a significant proportion of the tweets included emoticons or emojis (24.0%), which were used to express a wide range of positive and negative emotions. Moreover, emojis were used more frequently than emoticons to express emotions.

Swaney-Stueve, Gallo, and Blay (2016) have tested the use of emojis to investigate children’s feelings related to the consumption of lunch menus with the aim of reducing food waste in school canteens. In small focus groups with 8- to 12-year-olds, children were asked how their favorite food made them feel. Responses included “happy” and “guilty.” When asked about foods they did not like, responses included “sad,” “angry,” and “disappointed.” Children tasted foods and shared their thoughts using a list of words or emoji faces believed to be appropriate for children and food.

The children were very familiar with emojis and tended to use them more than words, because faces showed what they were trying to convey. Older children with increased verbal and reading skills felt the emojis were too ambiguous and preferred to use words for their responses, suggesting that the use of this approach should be carefully considering according to children’s age.

Despite further research being needed to better understand how characters may be used in consumer research with children, emojis and emoticons seem to be an easy and intuitive way to express emotions in a food context.

Emoji characters have several advantages. First, they are familiar to children and can be used in familiar environments (e.g., at home, at school). Second, they represent a potential nonverbal method to measure food-related emotions,

which can be particularly useful to test young children with reduced verbal skills and limited vocabulary. Nonverbal methods can be advantageous also for shy children who might be more willing to answer research questions if they do not have to answer directly to the adult. Another advantage is that when using emojis the research task is embedded in a game-like situation, which is known to increase children's motivation and attention span.

Finally, an important consideration is that emoticons and emojis may offer a standardized, universal way across countries of measuring children's emotions about foods, as well as capturing a level of satisfaction about a food that a child may be unable or unwilling to express (Swaney-Stueve et al., 2016).

4. RECOMMENDATIONS AND PRINCIPLES OF GOOD PRACTICE IN SENSORY TESTING WITH CHILDREN

Previous review articles (Guinard, 2001; Laureati, Pagliarini, et al., 2015; Popper & Kroll, 2005), as well as the ASTM guidelines (ASTM, 2013), provide an extensive overview of the factors that should be considered when performing sensory and consumer testing with children. This section is aimed at updating such information, extending the recommendations to new methodologies that have been developed and targeted to children.

4.1 Main Factors Influencing Test Reliability

4.1.1 Children's Age

Children's age range has always been reported as the most important factor to consider when choosing one method rather than another. A good overview of cognitive and motor skills from infancy to teen age is reported in the ASTM guideline (ASTM, 2013), whereby children are classified as preschoolers (3–5 years), early readers (5–8 years), preteens (8–12 years), and teenagers (12–15 years). However, even within the same age category, great intersubject variability can be observed. Diversity in skill levels can be especially pronounced in preteens, because it is quite common that in this age group basic skills, such as reading, are still not well developed, thus some children can overlap with early readers rather than preteens. Large differences in verbal capacity are also reported among young children; in addition, some of them may be reluctant to speak to unknown adults because of shyness (ASTM, 2013).

Despite age-related differences seeming to be an obvious concern in consumer research with children, one of the most common mistakes (that the present authors have also sometimes made) in consumer research with children is to consider children as a whole, homogeneous group, averaging the outcome provided by individuals that can differ substantially in their abilities. Therefore, we strongly recommend considering this aspect when involving children from a broad age range. Another recommendation is to consider individual skill development rather than chronological age. This can be done, for instance, using

questionnaires from developmental psychology (e.g., the Ages and Stages Questionnaire; [Squires, Potter, & Bricker, 1999](#)) that measure the child's development of communication, gross motor, fine motor, personal social, and problem-solving skills.

4.1.2 *The Context*

Another important factor that can strongly influence the reliability of the data when children are involved as consumers is the context in which the test is performed. Laboratory settings are not recommended with children because this environment can be perceived as “artificial,” thus reducing the ecological validity of the measurement. More realistic settings are encouraged, such as testing children at school during midmorning snacks or during meals in the canteen. Otherwise, other testing locations can be suitable, such as aggregation centers and summer camps. It is also important to present an engaging context to the children to overcome the tedious nature of the task and keep the children's attention high. For instance, [Nguyen and Murphy \(2003\)](#), to accommodate the attention span of 3-year-old children and to make the experiment game-like, developed a story-based method in which a doll named Jane needed children's help to decide which foods were of the same kind. [Kimmel et al. \(1994\)](#) specifically designed a testing environment for young children, providing tables of different colors and decorating the room with balloons and ribbons to create a game atmosphere.

In this sense, the novel concept of using emojis in sensory and hedonic methods with children can be successful because these characters are very familiar to children and can be used with computers or smartphones, thus complying with the gamification of the task.

4.1.3 *Interactions Between Adult and Child, and Child and Child*

Finally, the interactions with adults and peers should be considered with caution. Except when strictly necessary (e.g., with very young children), we believe that an excessive influence from third parties should be discouraged. Sources of interference for the child can be parents, teachers, and experimenters, but also siblings and schoolmates.

Although parents play a crucial role in their child's diet, relying solely on parent's reports underestimates the role of the child in the process ([Laureati, Bergamaschi, & Pagliarini, 2015](#)). In addition, parents may sometimes project their own behaviors onto their child ([Mata, Scheibehenne, & Todd, 2008](#)) or they can even unintentionally establish a pattern of answers that they believe would present their child in a positive manner to the experimenter ([ASTM, 2013](#)). Performing the test at school avoids the influence of parents, but caution should be taken to control for the impact of teachers, experimenters, and peers. Children can conform to their peers because of the need for social acceptance or they can give an answer because they believe it is the one the experimenter

requires. In this sense, children may overestimate the liking of food that is usually not very much appreciated (e.g., vegetables) because they want to please the evaluator. This fits well with unpublished results from our laboratory demonstrating that, keeping constant the testing location, the stimulus, and the procedure, the administration of the task by the experimenter produced significantly higher hedonic ratings for a fish formulation than when the task was administered by the children's teacher.

4.2 Choosing the Appropriate Method for Children

An overview of the appropriateness of classical and new sensory and hedonic methods with children is provided in [Table 13.3](#).

Different criteria can be used to establish the appropriateness of a method for children. Using different methodological approaches (e.g., hedonic scale and ranking) to demonstrate that children understood the task is commonly practiced in traditional consumer testing with children ([Laureati et al., 2016](#); [Léon et al., 1999](#); [Liem, Zandstra, & Thomas, 2010](#); [Olsen, Kildegaard, Gabrielsen, Thybo, & Møller, 2012](#)), but it can be difficult with new methodologies, which often do not have analogues.

Comparing children's self-reported assessments with those of adults might be problematic as well, because adults may have a different sensory perception and expectation of the product, thus if differences arise it is difficult to ascribe them to either a different perception between children and adults or a different understanding of the task.

Alternative criteria that we recommend to establish that a methodology is appropriate for data collection from young consumers are:

- verifying the correct discrimination of an a priori modified variable, such as texture in the CATA questions approach by [Laureati et al. \(2017\)](#);
- checking the congruence of the association of specific concepts to the samples, such as in the study of [De Pelsmaecker et al. \(2013\)](#), in which children clearly associated positive emotions with the most familiar and consumed products, or in the study of [Varela and Salvador \(2014\)](#), in which the concepts of healthy/don't like and unhealthy/like were correctly associated with vegetables and candies, respectively;
- testing the correct identification of the target and rejection of distracters in implicit memory paradigms ([Laureati et al., 2008](#); [Laureati & Pagliarini, 2013](#); [Laureati et al., 2011](#)).

5. CONCLUDING REMARKS AND FUTURE PERSPECTIVES

Reviewing the literature on the advances in consumer testing with children led us to the conclusion that recent methodology approaches such as sorting techniques, implicit paradigms to assess incidental learning and food memory, rapid

TABLE 13.3 Appropriateness of Classical and New Sensory and Hedonic Methods According to Children's Age

Method	Age Range (Years)				
	2–3	4–5	6–7	8–9	10–11
Classical Approaches					
Paired comparison	Yes ⁽¹⁾	Yes ⁽²⁾	–	Yes ⁽³⁾	Yes ⁽³⁾
Ranking	–	Yes ^(2, 4–6)	Yes ^(4–7)	Yes ^(4–5, 7–9)	Yes ^(5, 8–9)
Hedonic scales					
3-point	–	Yes ^(5–6)	Yes ^(5–6)	Yes ⁽⁵⁾	Yes ⁽⁵⁾
5-point	–	Yes ^(7,10)	Yes ⁽⁷⁾	Yes ^(7–9)	Yes ^(8–9)
7-point	No ⁽¹⁾	Yes ⁽¹¹⁾	Yes ^(12–14)	Yes ^(12–14)	Yes ^(12–14)
9-point	–	–	–	Yes ⁽¹⁵⁾	Yes ⁽¹⁵⁾
Unstructured linear	–	–	–	Yes ⁽³⁾	Yes ⁽³⁾
New Approaches					
Projective mapping and sorting	Yes ^(16–17)	Yes ^(16–19)	Yes ^(16,18–19)	Yes ^(18–19)	Yes ⁽¹⁸⁾
Implicit food memory paradigms	–	–	Yes ⁽²¹⁾	Yes ^(20–22)	Yes ^(20–22)
Check-All-That-Apply (emotion and sensory properties)	–	–	Yes ⁽²³⁾	Yes ^(23–25)	Yes ^(24–25)
Observational studies	Yes ⁽²⁶⁾	No ⁽²⁷⁾	No ⁽²⁷⁾ , Yes ⁽²⁸⁾	No ^(27,29) , Yes ⁽²⁸⁾	No ^(27,29) , Yes ⁽²⁸⁾
Eye tracking	–	–	–	Yes ^(30–31)	Yes ^(31–32)
Emojis	–	–	–	Yes ⁽³³⁾	Yes ⁽³³⁾

(1) Kimmel et al. (1994); (2) Liem et al. (2004); (3) Cordelle et al. (2005); (4) Liem and Mennella (2003); (5) Rollins et al. (2010); (6) Poelman and Delahunty (2011); (7) Liem and Zandstra (2010); (8) Kildegaard, Tønning, and Thybo (2011a); (9) Kildegaard, Tønning, and Thybo (2011b); (10) Donadini et al. (2012); (11) Caporale et al. (2009); (12) Pagliarini et al. (2005); (13) Laureati et al. (2011); (14) Laureati and Pagliarini (2013); (15) Moskowitz (2002); (16) Nguyen and Murphy (2003); (17) Tatlow-Golden et al. (2013); (18) Monnery-Patris et al. (2016); (19) Varela & Salvador, 2014; (20) Laureati et al., 2008; (21) Laureati et al., 2011; (22) Laureati and Pagliarini (2013); (23) Varela et al. (2016); (24) Laureati et al. (2017); (25) De Pelsmaecker et al. (2013); (26) Monnery-Patris et al. (2015); (27) Zeinstra et al. (2009); (28) Soussignan et al., (2012) 6–11; (29) de Wijk et al. (2012); (30) Folkvord et al., 2015; (31) Velasquez and Pasch (2014); (32) Werthmann et al. (2015); (33) Swaney-Stueve et al. (2016).

sensory techniques for descriptive analysis of food products, and implicit and explicit methods to study food-related emotions seem to be promising for use with the young consumer. Therefore, we encourage the implementation of new techniques with children and, in particular, we recommend the development and optimization of rapid sensory techniques that enable the characterization of food products by children (e.g., CATA and projective mapping).

The use of the Internet and social media for qualitative research with children and adolescents seems also to have great potential but remains almost unexplored.

From a methodological point of view, experimenters have to pay specific attention to the choice of the appropriate age range to be considered in their studies, and age-related differences should be explored even when specific age categories are involved. This aspect is almost never considered in empirical studies with children. Moreover, ecological settings should be preferred, limiting as much as possible interactions with the adults and encouraging self-assessment by children.

A better understanding of children's food perception and liking by using appropriate methodological approaches will benefit, on one hand, practitioners involved in food education, helping them to convey healthy and sustainable food behaviors. On the other hand, it will help food companies that will be able to meet children's taste and food safety requirements, thus contributing to tackling childhood overweight and obesity, which is a global emergency.

6. SOURCES OF FURTHER INFORMATION AND ADVICE

Traditional sensory and consumer research methods to be used with children are reviewed by Laureati, Pagliarini, et al. (2015), Popper and Kroll (2005), and Guinard (2001). The review by Laureati, Pagliarini, et al. (2015) also provides an overview of developments in consumer testing with children by describing new methodological approaches with children. The ASTM guidelines (ASTM, 2013) on testing with children have been updated and provide a comprehensive overview of practical advice and recommendations regarding how to conduct sensory and consumer testing with young consumers.

Journals that typically publish articles presenting methodological advances in sensory and consumer science or that critically discuss sensory methodologies, including children as respondents, are *Food Quality and Preference* (<http://www.journals.elsevier.com/food-quality-and-preference/>), *Appetite* (<http://www.journals.elsevier.com/appetite/>), and *Journal of Sensory Studies* ([http://onlinelibrary.wiley.com/journal/10.1111/\(ISSN\)1745-459X](http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1745-459X)).

The biannual Pangborn Sensory Science Symposium (<http://www.pangbornsymposium.com/>) and European Conference on Sensory and Consumer Research (Eurosense: <http://www.eurosense.elsevier.com/>) are recommended for both academic and food industry researchers interested in conducting sensory and consumer research with children.

Finally, the European Sensory Science Society (E3S: <http://www.e3sensory.eu/children/>) is a nonprofit organization promoting working groups dedicated to specific topics of the sensory field, one of which is the E3S Children Working Group. This working group aims to facilitate the exchange of research-based knowledge on the mechanisms influencing children's sensory perception and food preferences, and to promote the further development of methodologies appropriate for data collection from these young consumers.

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Chapter 14

Improving Food Sensory Quality
With and For Elderly Consumers

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1. INTRODUCTION

Within the context of an aging population, developing products that meet the specific needs of seniors while satisfying their sensory and hedonic expectations becomes a major challenge for the food industry as well as for society. As a result, it is highly important to use sensory assessment tools with elderly subjects “as their perceptions may not be interchangeable with those of adults who are under 60 years of age” (Murray, Delahunty, & Baxter, 2001).

Oral food consumption is by far the most important stage at which the sensory pleasure of a food can be perceived, appreciated, and accepted. It is widely acknowledged that aging is accompanied by a decline in the ability to perceive the taste and the odor of foods (Doty et al., 1984; Mojet, Christ-Hazelhof, & Heidema, 2001; Murphy, 1986) as well as by a deterioration in oral health such as tooth loss, decreased muscle strength, hyposalivation, and impaired swallowing induced by disease or drugs (Liu, Dion, Jurasic, Gibson, & Jones, 2012; Mioche, Bourdiol, & Peyron, 2004). However, beyond this overall effect of age, aging is accompanied by a large interindividual variability both for chemosensory abilities (Laureati, Pagliarini, & Calcinoni, 2008; Sulmont-Rosse et al., 2015) and for oral health (Vandenberghe-Descamps et al., 2016). Indeed, in addition to neurophysiological changes associated with the normal aging process, extrinsic factors may also have an impact on chemosensory and oral health decline, such as lifestyle factors, environmental factors, health, and medication. These factors, closely related to the life story of each individual, probably account for a large part of the variability observed in the elderly population (Mackay-Sim, Johnston, Owen, & Burne, 2006; Nordin, Almkvist, & Berglund, 2012; Sulmont-Rosse et al., 2015). To date, strategies to compensate for age-associated losses in chemosensory acuity have mainly explored flavor enhancement (i.e., deliberately adding flavor compounds to a food), providing mixed results (see Doets & Kremer, 2016; Song, Giacalone, Johansen, Frost, & Bredie, 2016; Sulmont-Rossé, Maître, & Issanchou, 2010 for a review). Strategies to improve nutrition in response to oral disorders consist in providing elderly people with “texture-modified” foods, in the form of chopped, blended, or pureed foods, which are often unattractive and not very palatable. Furthermore, food fortification (i.e., deliberately increasing the content of an essential nutrient in a food, so as to improve the nutritional quality of the food supply and provide a health benefit) is a common management approach for elderly people with reduced appetite. However, existing market solutions are mainly sweet oral nutritional supplements, for which liking and intake are often poor, because of unacceptable mouthfeel and flavor characteristics over full portion sizes (Methven et al., 2010).

Food industries and catering services have made efforts in recent years to improve food offerings dedicated to elderly people (in particular for texture-modified foods and fortified foods). However, to the best of our knowledge, the stakeholders seldom measure sensory expectations and preferences in elderly people through formal tests, and in particular in frail and dependent elderly

people, despite their being the main target for texture-modified and fortified foods. At best, catering services carry out a satisfaction survey on the overall quality of the food and service or they get feedback from their guests on a new product or a new recipe at the end of the meal in an informal manner. However, such practices suffer from social desirability bias: the present generation of elderly people has been educated not to complain about food (Doty, 1991) and older people are often reluctant to complain about a service on which they depend (CLCV, 2012).

In this chapter, we will describe a methodology following the reverse engineering principle that we have used to improve the sensory quality of food according to the sensory expectations and preferences of elderly people (case study). This methodology was applied to three types of dishes: a ready-to-eat dish from French familial cuisine (“*blanquette de veau*”—a veal stew in white sauce), a texture-modified food (pureed beef–carrots), and a fortified food (high-protein and energy-dense vanilla custard). Reverse engineering consists in extracting knowledge from an object and reproducing it based on the extracted information. In fact, Ries (2012) recommends developing new products according to a tailored management process in three phases, namely, *learn* (about consumers’ needs and expectations), *produce* (products that may fulfill consumers’ needs and expectations), and *measure* (whether products fit consumers’ needs and expectations), through an iterative process. This strategy aims at increasing the success of products on the market. In coherence with this method, first a panel of elderly people was asked to taste and provide feedback on food products available on the French market (*learn*: qualitative phase). Then, four variants were developed on the basis of qualitative results for one ready-to-eat dish (veal *blanquette*), one texture-modified food (pureed beef–carrots), and one dessert (high-protein and energy-dense vanilla custard) (*produce*: food development phase). Finally, a second panel of elderly people rated their liking for each variant on a scale (*measure*: quantitative phase).

2. LEARN—QUALITATIVE PHASE

Six focus groups (8 ± 2 elderly people in each) were carried out with 54 elderly participants living at home (21 men and 33 women; mean age 70.5 years; age range 65–88 years). For this first phase, three ready-to-eat dishes (omelet with potatoes, trout fillet with chives and rice, veal *blanquette* with rice), three texture-modified foods (pureed beef–carrots, pureed veal–endives, pureed pork–prunes), and six desserts (vanilla custard, high-protein and energy-dense vanilla custard, two high-protein, energy- and mineral-dense vanilla custards, two high-protein and energy-dense apple purees) were selected. All of these items were available on the French market (mass distribution for ready-to-eat dishes and apple puree; medical market for texture-modified foods and fortified custard). Each focus group was served one ready-to-eat dish, one texture-modified food, and two desserts so that each dish was assessed by two focus

groups. Participants were asked to taste each food product and to indicate what they liked in the product, what they did not like, and how the product could be improved. The moderator directed the flow of the discussion and ensured that all of the important issues were discussed. Sessions were run at lunch or dinner time in a sensory room.

Independent elderly people who took part in the focus group reacted to this method positively, expressing themselves easily. They suggested several improvements in the food products that were being tested, including comments on ingredients (e.g., “there are not enough mushrooms”, “entire mushrooms rather than sliced mushrooms”), texture (“meat not tender enough”, “sticky texture”), seasoning and flavor (“blend sauce should be flavored with spices”, “caramel rather than vanilla flavor”), aspect (“color too dark”), as well as cooking tips (“omelet should be quite moist; potatoes should be sautéed”).

3. PRODUCE—FOOD DEVELOPMENT PHASE

On the basis of these results, four variants were developed for one ready-to-eat dish (veal blanquette), one texture-modified food (pureed beef–carrots), and one dessert (high-protein and energy-dense vanilla custard). Improvements targeted either one or two sensory dimensions, (i.e., texture, taste, or aroma) or all the sensory characteristics of the product (holistic improvement). For the veal blanquette, the meat’s texture was improved in all four variants as it appeared to be a prerequisite in improving the sensory quality of a meat dish in all the focus groups. Furthermore, the focus groups extensively discussed the fact of having pureed foods that could be easily recognized, and thus having pureed beef and pureed carrots side by side (and not mixed altogether as was the case for the market product). Consequently, for the texture-modified food, one of the variants consisted in separated pureed beef and pureed carrots. For each food, variants were submitted to a sensory profile analysis. Sensory profiles were run by assessors specifically trained on the corresponding product (veal blanquette: 10 assessors, 9 descriptors—2 visual attributes, 4 texture attributes, 2 flavor attributes and 1 taste attribute, one replication; pureed beef–carrots: 14 assessors, 14 descriptors—5 texture attributes, 4 taste attributes, 4 flavor attributes and 1 trigeminal attribute, two replications; custard: 10 assessors, 20 descriptors—3 visual attributes, 7 texture attributes, 1 taste attribute and 9 flavor attributes, one replication). Each sensory profile was performed in a different sensory lab according to their usual practices, which explains differences between methodologies. Veal blanquette variants and custard variants were evaluated by the industrial company in charge of developing the products. Pureed beef–carrots variants were evaluated at the French National Institute for Agricultural Research (INRA) as the producer did not have any sensory facilities. The results allowed the improvements to be checked for consistency with the development paths proposed by the elderly people in the qualitative phase. A brief description of each variant is provided in [Table 14.1](#).

TABLE 14.1 Food Products Tested During the Quantitative Phase

	Ready-to-Eat Food	Texture-Modified Food	Fortified Food
	Veal Blanquette	Pureed Beef–Carrots	High-Protein and Energy-Dense Vanilla Custard
Standard	Market product	Market product	Market product
Improved	+Tex	+Tex	+Tex
	Soft meat,	Smoother and less sticky texture	Fluid texture
Improved	+Tex+Tas	+Tas	+Tas
	Soft meat, taste improvement (salt, citrus acidity, pepper)	Enhancement of taste (salt, pepper)	Enhancement of sweetness
Improved	+Tex+Aro	+Tas+Aro	+Aro
	Soft meat, enhancement of gravy's aroma	Enhancement of saltiness and aroma	Improvement of vanilla aroma
Improved	+Hol	+Sep	+Hol
	Soft meat, whole mushrooms, crunchier mushrooms and carrots, taste improvement, enhancement of gravy's aroma	Pureed beef and pureed carrots presented side by side (not mixed altogether)	Fluid texture, improvement of vanilla aroma
Unpleasant	Without added salt	Without added salt	Pasty texture, low in sweetness, less aroma

For each type of food, the product set included the market product (standard), three variants improved in one or two sensory dimensions (texture, +Tex; taste, +Tas; aroma, +Aro), one variant improved in all the sensory characteristics of the product (+Hol), or by separating meat and vegetable purees for the texture-modified food (+Sep), and one a priori unpleasant variant.

4. MEASURE—QUANTITATIVE PHASE

4.1 Method

4.1.1 Participants

One hundred three elderly people living at home (44 men and 59 women; mean age 72 years; age range 65–82 years) and 63 elderly people living in a nursing home (8 men and 55 women; mean age 86 years; age range 67–98 years) were

recruited. The recruitment criteria were as follows: older than 65 years, no acute pathological episode at the time of the survey, no food allergies, no dysphagia, not on a doctor-prescribed diet, and scoring at least 20 on the Mini Mental State Examination (MMSE) (Folstein, Folstein, & Mchugh, 1975). The MMSE screens for cognitive impairment: scores greater than or equal to 26 points (of 30) indicate normal cognition. Below this, scores can indicate severe (≤ 15 points), moderate (16–19 points) or slight (20–25 points) cognitive impairment (Derouesné et al., 1999). Participants who self-reported a congenital anosmia or an anosmia due to head injury and participants who suffered from sinusitis or a severe respiratory infection at the moment of the survey were also excluded. An interview was carried out with each candidate to ensure that he or she met the inclusion criteria. The experimental protocol of the survey was approved by the French Ethics Committee for Research (CPP Est I, Dijon, No. 2011/16, AFSSAPS No. 2011-A00277-34). In accordance with the rules of ethics, all of the participants received written and oral information on the survey before signing a consent form.

4.1.2 Food Products

For each type of food (ready-to-eat dish, texture-modified food, fortified food), the product set included six variants (Table 14.1):

- the standard variant (Std) that was used in the qualitative phase (i.e., product available on the French market);
- the four variants that were developed from the proposals made by the focus groups;
- one a priori unpleasant variant (Unp). For the veal blanquette and the pureed beef and carrots, the unpleasant variants corresponded to the standard recipe without added salt (foods dedicated to people on a no-salt diet). For the custard, the unpleasant variant was obtained by making the texture thicker and decreasing the sweetness and the flavor of the standard recipe.

Unpleasant variants were added to control for positive bias often observed with elderly people, and in particular dependent elderly people (Maitre, Symoneaux, & Sulmont-Rossé, 2015). On average, elderly people tend to give higher liking scores than young people (Cordelle, Lange, & Schlich, 2004; D’Hauteville, Aurier, & Sirieix, 1997; Kälviäinen, Roininen, & Tuorila, 2003; Tuorila, Anderson, Martikainen, & Salovaara, 1998). This could be due to the fact that the present generation of elderly people has been educated not to complain about food (Doty, 1991). This could also be due to the fact that elderly people want to please the investigators, who are “taking care” of them during the sensory tests (this positive emotional context is even stronger in nursing homes, where sensory tests represent a disruption in the daily routine and an opportunity to “chat” with a “visitor”).

4.1.3 Hedonic Rating

Three sessions were carried out, one per food product. At each session, participants were served the six variants using a sequential monadic procedure. The

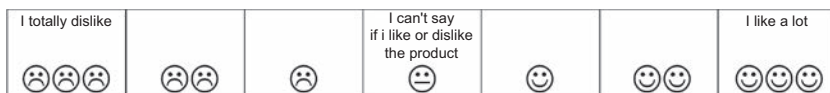


FIGURE 14.1 Hedonic scale designed for dependent elderly people (Maitre et al., 2015).

products were presented in the order determined by a Williams Latin square design. The participants tasted each product and evaluated their liking for the product on a 7-point categorical scale combining labels and pictograms, which was previously designed and validated for dependent elderly people (Fig. 14.1; Maitre et al., 2015).

Sessions were conducted in a sensory lab for the independent elderly people or in a meeting room at the nursing home for the dependent elderly. Sessions were carried out at lunch time for the veal blanquette and pureed beef–carrots (participants were offered a dairy product and a dessert before leaving) and at the afternoon collation for the custard. Veal blanquette and pureed beef–carrots were heated to the temperature of $68 \pm 2^\circ\text{C}$ before being served (portion to be served: 60 g). Custard samples were served at the temperature of $11 \pm 1^\circ\text{C}$ (portion to be served: 125 g). After each tasting, the participants were requested to take a break and rinse their mouth out with plain water. Samples were coded with three-digit numbers.

4.1.4 Data Analysis

The hedonic scores were converted into scores varying from 0 (“I totally dislike”) to 6 (“I like a lot”). All statistical analyses were conducted using SAS/STAT (1990). Analyses of variance (ANOVA) were performed using the general linear model procedure of SAS/STAT (type III sum of squares). Least-squares means were computed for each factor and submitted to multiple comparison analysis using the LSMEANS option. The hierarchical cluster analysis (HCA) was conducted using SPAD software (7.4; COHERIS, Suresnes, France). Means (M) were associated with the standard error of the mean (SEM). The threshold for significance was set at 5%.

4.2 Results

4.2.1 General Overview

An overview of the hedonic results is given in Fig. 14.2, using box plots per variant and per type of food. For each food, hedonic scores were submitted to an ANOVA with *variant* and *category* (living at home; nursing home) as fixed factors and *participant* as the random factor. A significant *variant* effect was observed for the three foods (veal blanquette, $F_{5,765} = 22.0$, $P < .001$; pureed beef–carrots, $F_{5,739} = 31.6$, $P < .001$; vanilla custard, $F_{5,800} = 6.0$, $P < .001$). The a priori unpleasant variants were associated with the lowest liking scores for the three foods. For the veal blanquette, all the improved variants but +Tex+Aro obtained higher liking scores than the standard. No significant difference was

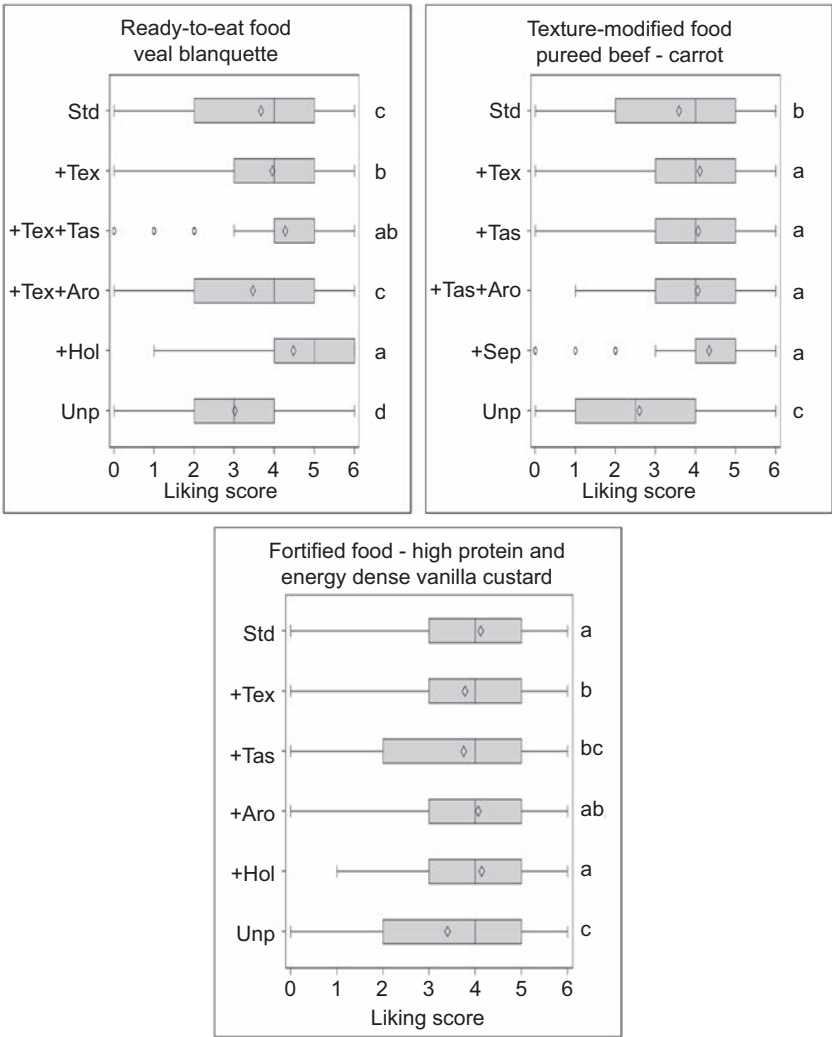


FIGURE 14.2 For each food, box-plot distributions of liking scores per variant are shown. The left and right of the box correspond to the 25th and 75th percentile, respectively. The vertical band and the diamond correspond to the median and the mean, respectively. The ends of the whiskers represent the lowest/highest data still within the 1.5 interquartile range. Any data not included between the whiskers are plotted as outliers with a dot. +*Aro*, aroma; +*Hol*, all sensory characteristics of the product; +*Sep*, meat and vegetable purees separated for the texture-modified food; *Std*, standard; +*Tas*, taste; +*Tex*, texture; *Unp*, unpleasant.

observed between the variant +*Tex* + *Aro* and the standard. For the pureed beef-carrots, all the improved variants obtained higher liking scores than the standard. No significant difference was observed between the improved variants. Finally, for the vanilla custard, the improved variants did not score higher than

TABLE 14.2 *F* and *P* Values for the *Variant* Effect Per Product and per Dependence Category

	Independent Elderly People	Institutionalized Elderly People
Veal blanquette	$F_{5,500} = 15.91$ ($P < .001$)	$F_{5,265} = 9.52$ ($P < .001$)
Pureed beef–carrots	$F_{5,450} = 23.08$ ($P < .001$)	$F_{5,289} = 11.23$ ($P < .001$)
Vanilla custard	$F_{5,505} = 5.94$ ($P < .001$)	$F_{5,295} = 1.95$ ($P = .08$)

the standard. The variants +Aro and +Hol were as appreciated as the standard, while the variants +Tex and +Tas were less appreciated than the standard.

A significant *category* effect was observed for the veal blanquette ($F_{1,153} = 5.38$; $P < .05$), but not for the pureed beef–carrots ($F_{1,148} = 0.08$; $P = .77$) nor for the vanilla custard ($F_{1,160} = 1.25$; $P = .27$). On average, institutionalized people had higher liking for the blanquette ($M = 4.0$; $SEM = 0.08$) than autonomous elderly people ($M = 3.7$; $SEM = 0.06$). No significant *variant* $\times$ *category* interaction was observed. To further investigate the impact of dependence on discrimination ability, liking scores were submitted to an ANOVA with *variant* and *participant* as fixed factors per category (Table 14.2). Results showed a decrease in the discrimination level with dependency, but significant differences between the products were still observed for the institutionalized elderly people (only a tendency for the custard).

4.2.2 Consumer Segmentation

As the box plot revealed large between-subject variations, centered liking scores for each food were submitted to an HCA (Euclidean distance, Ward criteria, k-means consolidation), and the number of clusters was chosen based on the dendrogram. As the previous analysis did not reveal any *variant* $\times$ *category* interaction, all participants together (independent and dependent) were included in a unique HCA. The clustering analyses revealed three, four, and three clusters for veal blanquette, pureed beef–carrots, and vanilla custard, respectively. None of the clusters was associated with a significant higher percentage of dependent elderly people. For the veal blanquette, clusters 1, 2, and 3 included 32%, 27%, and 45% of dependent people, respectively ($\chi^2 = 4.41$; $P < .05$). For the pureed beef–carrots, clusters 1, 2, 3, and 4 included 44%, 36%, 38%, and 37% of dependent people, respectively ($\chi^2 = 0.51$; $P < .05$). And for the custard, clusters 1, 2, and 3 included 28%, 38%, and 41% of dependent people, respectively ($\chi^2 = 1.44$; $P < .05$).

Regarding the veal blanquette (Fig. 14.3), the three clusters significantly preferred the variant that was improved on all the sensory characteristics of

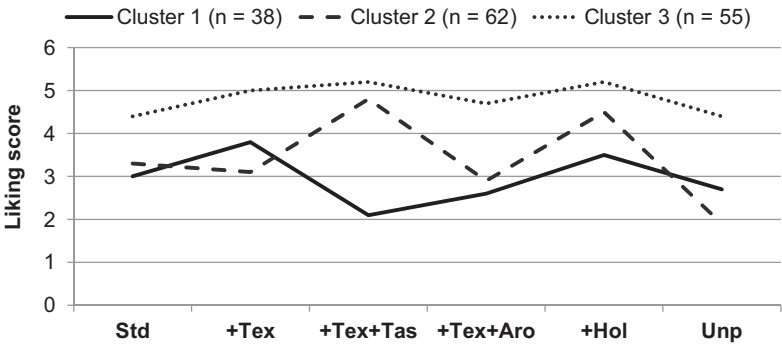


FIGURE 14.3 Ready-to-eat food: liking scores per cluster and per variant for the veal blanquette. Each cluster is associated with the number of participants belonging to that cluster (n). +Aro, aroma; +Hol, all sensory characteristics of the product; Std, standard; +Tas, taste; +Tex, texture; Unp, unpleasant.

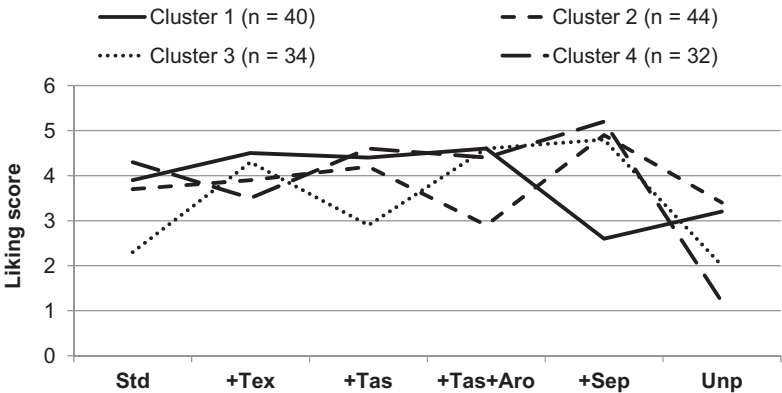


FIGURE 14.4 Texture-modified food: liking scores per cluster and per variant for the pureed beef-carrots. Each cluster is associated with the number of participants belonging to that cluster (n). +Aro, aroma; +Sep, meat and vegetable purees separated for the texture-modified food; Std, standard; +Tas, taste; +Tex, texture; Unp, unpleasant.

the product (+Hol) over the standard. The variant +Tex +Tas segmented cluster 1 from the two other clusters: this variant was the least liked variant in cluster 1, while it was equally liked compared to the variant +Hol in clusters 2 and 3. Clusters 2 and 3 mainly differed in the way they scored the variants: on average, cluster 3 gave higher liking scores than cluster 2 ($t=13.49$; $P<.001$), while they were less discriminant (cluster 3, $F_{\text{variant}}=8.01$; $P<.001$; cluster 2, $F_{\text{variant}}=37.68$; $P<.001$).

Regarding the pureed beef-carrots (Fig. 14.4), the variant with separated meat and vegetable purees (+Sep) segmented cluster 1 from the three other clusters: this variant was the least liked in cluster 1, while it was highly liked in the other clusters. For clusters 2 and 4, the separated variant was associated with the

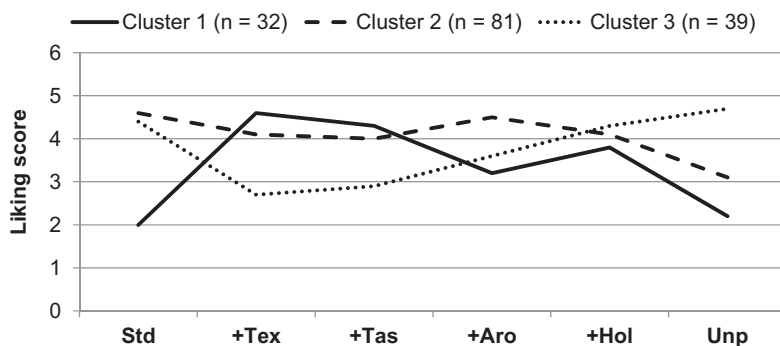


FIGURE 14.5 Fortified food: liking scores per cluster and per variant for the high-protein and energy-dense vanilla custard. Each cluster is associated with the number of participants belonging to that cluster (n). +Aro, aroma; +Hol, all sensory characteristics of the product; Std, standard; +Tas, taste; +Tex, texture; Unp, unpleasant.

highest liking score. Thus, both clusters gave similar liking scores to the standard and the variant +Tas. However, cluster 2 gave a similar liking score to the standard and to +Tex but disliked +Tas+Aro. Conversely, cluster 4 gave similar liking scores to the standard and +Tas+Aro but disliked +Tex. For cluster 3, all the improved variants obtained higher liking scores than the standard. The variant without added salt (Unp) was disliked by all the clusters, in particular cluster 4.

Regarding the fortified vanilla custard (Fig. 14.5), clusters were mainly segmented by the variants Std, Unp, +Tex, and +Tas. Indeed, cluster 1 gave the highest liking scores to +Tex and +Tas but disliked the Std and Unp variants. Conversely, cluster 3 gave the highest liking scores to the Std and Unp variants but disliked +Tex and +Tas. Interestingly, the variants Std, Unp, and +Tex differed on texture, with +Tex being fluid and the Std and Unp variants being thick. Consequently, cluster 1 seemed to favor fluid custard, while cluster 3 seemed to favor thick and not too sweet custard. Finally, cluster 2 preferred Std and +Aro over +Tex, +Sav, and Unp. This cluster may give more importance to variants' flavor than to texture.

5. DISCUSSION

5.1 The Reverse Engineering Methodology, a Promising Strategy for Developing Food Products Targeting the Elderly

As a first conclusion, the reverse engineering methodology followed up in this study proved to be efficient, at least for the ready-to-eat food (veal blanquette) and the texture-modified food (pureed beef-carrots). Indeed, the variants improved on the whole sensory dimension (+Hol) obtained higher liking scores than the variant available on the French market at the time of the study (Std). For the fortified vanilla custard, we did not observed any increase in

liking for the improved variant compared to the standard variant. This may be due to the difficulties encountered in reformulating this product, given that this product should comply with strict nutritional regulations to be acknowledged as an oral nutritional supplement and reimbursed for by French health insurance. Interestingly, a similar approach was used by [den Uijl, Jager, Zandstra, de Graaf, and Kremer \(2016\)](#) to develop two protein-enriched recipes for a traditional Dutch meat dish, a “cozy” recipe tailored to the expectations of senior consumers who eat mainly for coziness and social interaction (“cozy socializers”) and a “physical” recipe tailored to the expectations of senior consumers who eat mainly for nutrients and physical needs (“physical nutritioners”). As in the present experiment, den Uijl and colleagues carried out a qualitative phase with each senior consumer segment to determine their expectations, to further develop the two dishes (one per segment). Finally, they ran a home use test in which they consumed and assessed these two dishes. The results did not show any *segment* $\times$ *dish* interaction, meaning that the two senior consumer segments (cozy socializers and physical nutritioners) liked the “cozy” and the “physical” dishes equally. However, liking scores for both dishes were quite high (close to 80 on a 100-point rating scale), proving the efficiency of such methodology for reformulating traditional dishes to fit with the nutritional needs of the elderly population.

5.2 The Elderly Population Is Characterized by a Large Interindividual Variability in Food Preferences

As a second conclusion, this experiment highlighted a large interindividual variability in food preferences among the elderly population. Variability in food preferences is observed in all stages of life and elderly people do not escape the rule. Food preferences are affected by numerous factors, such as biological, physiological, psychological, and societal factors, which might account for this variability ([Vabo & Hansen, 2014](#)). As most of our food preferences are learned through experiences ([Rozin & Vollmecke, 1986; Zellner, 1991](#)), it may be assumed that increase in age goes along with an increased number of food experiences, which in turn leads to an increase in interindividual variability. In fact, family resemblance studies for individual food items have even demonstrated modest or no correlation between first-degree relatives (see, for instance, [Birch, 1980; Rozin, 1991](#)). Furthermore, [Jilani, Intemann, Hebestreit, and Ahrens \(2016\)](#) observed lower correlation between taste preferences of older siblings (>12 years of age) than between those of younger siblings (<12 years of age). Consequently, it may be assumed that variability in food preferences is higher in the elderly than in younger populations. Indeed, aging does not take the same toll on physiological processes, resulting in a large interindividual variability in perception, which may have an impact on food preferences. Furthermore, elderly people may have undergone more food experiences than younger people, just because of a longer life span. In view of this large variability in food preference, it is important to achieve a varied food supply in

response to the elderly population's needs. Interestingly, having pureed beef and pureed carrots side by side (and not mixed altogether) was valued by some participants, but 27% of the participants did not like this variant very much ($M=2.60$; $SEM=0.23$).

5.3 Multidimensional Approaches Should Be Favored Rather Than Targeting One Sensory Dimension

Finally, strategies to compensate for age-associated losses in chemosensory acuity have mainly explored flavor enhancement (i.e., deliberately adding flavor compounds to a food). Flavor enhancement has proved to be effective in food acceptability: several authors have observed that adding a flavor compound to a food actually increases liking scores among elderly people (De Jong, De Graaf, Van Staveren, 1996; Griep, Mets, & Massart, 1997; Koskinen, Kälviäinen, & Tuorila, 2003; Kremer, Bult, Mojet, & Kroeze, 2007a, 2007b; Laureati et al., 2008; Schiffman & Warwick, 1988). For instance, Schiffman and Warwick (1988) presented elderly participants with three food samples. One of these was not enhanced, while the other two were enhanced with the same flavor at different concentrations or with different flavors. The participants were asked to taste each of the three samples and to choose the one they preferred. On average, 75% of the elderly participants favored an enhanced sample. However, flavor enhancement seldom improves food intake in elderly people (see Doets & Kremer, 2016; Sulmont-Rossé et al., 2010, for a review). Schiffman and Warwick (1993) compared food intake of retirement home residents when they ate plain food versus when they ate flavor-enhanced foods. The results indicated that the addition of flavors significantly increased consumption of only 3 of 30 foods. Mathey, Siebelink, de Graaf, and van Staveren (2001) observed that daily dietary intake decreased in a control group, while it remained stable in a group who ate flavor-enhanced foods for 16 weeks. However, when Essed, van Staveren, Kok, and de Graaf (2007) replicated this study a few years later, flavor enhancement did not lead to a higher dietary intake. It should be noted that in most of the studies that have tested the effectiveness of flavor enhancement, flavor compounds and enhanced concentrations were chosen by the experimenters, without exploring the elderly subjects' expectations and preferences. Koskinen et al. (2003) and Bellisle et al. (1991) even chose the flavor concentrations for the enhanced foods using data collected from a young panel. However, even if taste and aroma enhancements have been drawn from the input of elderly people in the present experiment (qualitative phase), flavor enhancement seldom influenced food liking. The taste and aroma of enhanced purees were preferred to the standard, but the aroma-enhanced custard was as liked as the standard and the taste-enhanced custard was even less liked than the standard. In fact, it was the variant that was improved on three sensory dimensions (taste, aroma, and texture) that got the highest liking score. This pleads in favor of a multidimensional approach when developing food for the elderly population (see also Kremer, Holthuysen, & Boesveldt, 2014).

5.4 Methodological Recommendations

Running focus groups or hedonic ratings with elderly people requires some adjustments (see [Methven, Jiménez-Pranteda, & Lawlor, 2016](#) for a review). Even within the framework of normal aging (with no pathology), age goes with slower cognitive and motor functions as well as with tiredness in people. Consequently, several precautions should be taken for them to feel comfortable in their taster role. Tests should be simplified and the workload during tasting sessions should be reduced ([Maitre et al., 2015](#)). Instructions and questionnaires should be easy to read (airy layout, large print, large scales) so as not to put seniors suffering from visual impairment in an awkward position. As many old people suffer from hearing impairment, it is recommended to give the instructions collectively, then to individually check that each participant understood well. Some elderly people may not be able to write (which frequently happens in nursing homes). In that case, an experimenter should take notes of the participant's answers without influencing him or her. As a rule of thumb, we serve no more than six different food products in a session with older people. It is also recommended to check that the total amount of food ingested does not exceed the size of a standard portion as elderly people often have digestion problems.

A high heterogeneity is seen among the elderly population, in particular in terms of sensory perception ([Sulmont-Rosse et al., 2015](#)), oral health status ([Vandenberghe-Descamps et al., 2016](#)), and cognitive functions ([Alaphilippe & Bailly, 2013](#)), three factors at the heart of food assessment. Consequently, recruiting a panel of healthy and autonomous elderly, i.e., a panel of subjects older than 75, presenting no pathology, taking no drugs, and with good sensory, masticatory, and cognitive aptitudes, is challenging. However, it is also difficult to recruit people with specific problems (such as people suffering from malnutrition or from dysphagia) as they are usually frail and dependent and therefore less willing to take part in this type of study and/or cognitively not capable of carrying out sensory tests. In fact, this can be seen as a limiting factor in applying the present methodology for the development of products meeting the specific needs and/or disabilities of elderly people (such as fortified food or texture-modified food). This study as well as a previous study ([Maitre et al., 2015](#)) revealed a decrease in the hedonic discrimination level with dependency, but product ranking was similar between independent elderly people and institutionalized elderly people. When searching in the PubMed and Web of Science databases to 2014, [Methven et al. \(2016\)](#) found 73 papers related to hedonic measures in older people. Over these 73 papers, 59 used a category hedonic liking scale and/or a visual analogue liking scale. Over these 59 papers, only 16 carried out hedonic measurement with both older people and elderly patients suffering from a specific disease (e.g., cancer patients, Alzheimer's disease) or a specific disability (e.g., olfactory dysfunction, dysphagia). In most of these studies, pleasantness did not differ between the elderly patients and the elderly controls. For instance, [Stahman et al. \(2001\)](#) asked two groups of elderly

people with and without impaired swallowing to rate their liking for different types of pureed peach. They did not observe any *group* effect or *group* $\times$ *product* interaction on liking score. However, one should be cautious before recruiting a convenience sample of healthy elderly people to assess food products dedicated to elderly people with specific problems. In fact, studies that have compared the hedonic ratings of healthy elderly people with those of frail elderly people are still too scarce to support a definitive conclusion.

Finally, a bias toward the positive side of the scale was frequently observed with elderly people, and in particular dependent elderly people. On average, elderly people give higher liking scores than young people (Cordelle et al., 2004; D’Hauteville et al., 1997; Kälviäinen et al., 2003; Tuorila et al., 1998), and dependent elderly people give higher liking scores than independent elderly people (Maitre et al., 2015). This could be due to the fact that the present generation of elderly people has been educated not to complain about food (Doty, 1991). This could also be due to the fact that elderly people want to please the investigators, who are “taking care” of them during the sensory tests. This positive emotional context is even stronger in nursing homes, where sensory tests represent a disruption in the daily routine and an opportunity to “chat” with a “visitor”. In an attempt to prevent this bias, we tried to make the respondents comfortable with the idea of giving a low hedonic score to the products in the instructions. We also added an *a priori* unpleasant variant in the product series. These precautions were at least partly successful, as dependent people gave higher liking scores than autonomous people for the blanquette but not for the two other products. However, even if the unpleasant variants were associated with the lowest liking score for the three products, these liking scores were close to the middle of the scale (veal blanquette, $M=3.01$, $SEM=0.14$; pureed beef–carrots, $M=2.60$; $SEM=0.14$; fortified vanilla custard, $M=3.40$; $SEM=0.13$). Of course these scores might reflect the fact that participants did not perceive the *a priori* unpleasant variants as *very* unpleasant. But this might also reflect the fact that elderly people are reluctant to use the negative side of liking scales.

6. CONCLUSION

This chapter proposes a methodology following the reverse engineering principle to overcome the gap in the current food supply for food adapted to elderly people’s expectations. Given the fact that experimental conditions were adapted to fit with elderly people’s capacities and disabilities, the present experiment demonstrates that improving the sensory quality of foods dedicated to elderly consumers with input from elderly consumers is possible and efficient. In fact, in the context of an aging population, the development of products meeting an elderly person’s nutritional needs while taking into account functional capacities and sensory preferences is a major challenge for the food industry as well as for society.

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ACKNOWLEDGMENTS

This study is part of AUPALESENS—Improving the pleasure of elderly people for better ageing and to fight against malnutrition—funded by the French National Research Agency (ANR-09-ALIA-011-02). This work was also supported by grants from the Regional Council of Burgundy France (PARI Agral 1) and the European Funding for Regional Economical Development (FEDER). The authors thank Pauline De Facq, Françoise Durey, Christophe Laura Gimaret, Martin, Anaïs Mesnier, Catherine Ouvrad, Corinne Patron, Isabelle Saillard, and Jérémy Tavarès for their help during the experiments; Sylvie Issanchou and Virginie Van Wymelbeke for providing advice; and D'Aucy, Nutrisens and Lactalis for the work they did on the recipes to provide the variants.

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Chapter 15

Designing Consumer Research Studies for Low-Income Populations

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Chapter Outline

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1. INTRODUCTION

Sensory and consumer science research generally focuses more on the needs of prosperous, food-secure societies in which consumers expect optimum enjoyment of food (Tuorila & Monteleone, 2009). Food acceptability studies for poor consumers in low- and middle-income countries have been neglected (Sosa & Hough, 2006; Sosa, Martinez, Marquez, & Hough, 2008; Tomlins, 2013).

However, the reality is that whatever socioeconomic class, people desire to eat tasty food (Chase, Reicks, Smith, Henry, & Reimer, 2003) that provides value for money (Ismail & Kleyn, 2012) and that is typical of their culture and tradition (Alkon et al., 2013). The application of sensory and consumer science to optimize products for the poor and the development of suitable test methods for this purpose deserve much more attention.

Income level is a relative concept and what is considered low income in one part of the world differs much from that in another part. There is major inequality in terms of income and living standards among populations in many parts of the modern world. Socioeconomic status is generally understood to explain the social position of an individual or group in society. It is measured as a complex combination of education, income, assets, and occupation (Howe et al., 2012). The absolute income and/or education level used to describe consumers of low income or low socioeconomic status will clearly differ widely depending on the country, region, or context of interest. Consumers with low socioeconomic status represent a substantial part of the world population. The distribution of poor consumers with a relatively low level of education is concentrated in the developing world, which includes many countries in sub-Saharan Africa, Asia, and Latin America (Fields, 2011). Rapid urbanization has led to the establishment of large low-income communities in and around almost every major town and city in the developing world. Interestingly though, Sumner, Klugman, Leo, Steven, and Pollard (2012) argued that the distribution of global poverty is rapidly changing, with much of the world's poor, in terms of absolute numbers, no longer living in countries classified as low income. It is estimated that a major part of this sector of up to a billion people lives in middle-income countries. However, it is not the intention to discuss, define, or classify here who is poor and who is not. The diverse groups of relatively poor consumers offer huge economic potential for food businesses (Singh & Kathuria, 2016). Yet, the contributions that low-income consumers can make to new product development remain underexplored (Krämer, 2015).

Universally food and nutrition security remains a major challenge for many consumers. In developing regions it is estimated that 12.9% of the population is undernourished, with sub-Saharan Africa having the highest prevalence (percentage of population) (Food and Agriculture Organization of the United Nations, 2015). Poverty is a major contributing factor. Medical care is often limited and available food supplies contribute directly to the fight against nutrition-related diseases and poor quality of life. The exploration of underutilized and sustainable food sources and the prevention of food losses and waste due to undesirable sensory properties are options to address these challenges. Insights into what are considered acceptable and preferred ingredients, foods, and meal combinations and better understanding of the social and cultural context of food use and consumption are vital for product development. Tailoring the sensory properties of affordable nutritious foods to optimize appeal is essential. Sensory and consumer research has an important role to play. Many programs

focus much effort on nutrient optimization of food for low-income populations yet acceptance is primarily based on whether sensory properties are liked or disliked (Sosa & Hough, 2006). Nutritional or health benefits come as an afterthought to resource-constrained consumers. Whereas the investigation of socioeconomic factors related to dietary intake and food choice has received much attention (Akarolo-Anthony et al., 2013; Darmon & Drewnowski, 2008; Kontinen & Sarlio-la, 2016), consumer research to understand responses to the sensory properties of foods has received little attention in low- and middle-income countries.

The objective here is to give insights into what is needed for the design and execution of research studies aimed at collecting quantitative information reflecting the opinions of low-income consumers. In the context of this review, the level of schooling and/or level of literacy, as well as the standard of living, of the consumers are poor to very poor. The examples used are primarily based on experience obtained while conducting food product tests with consumers in the southern African context.

2. CHARACTERISTICS OF CONSUMERS OF LOW SOCIOECONOMIC STATUS

Some of the characteristics of consumers in a low-income context that may influence the design of consumer research studies are summarized in Fig. 15.1. In low- and middle-income countries clear stratification of socioeconomic

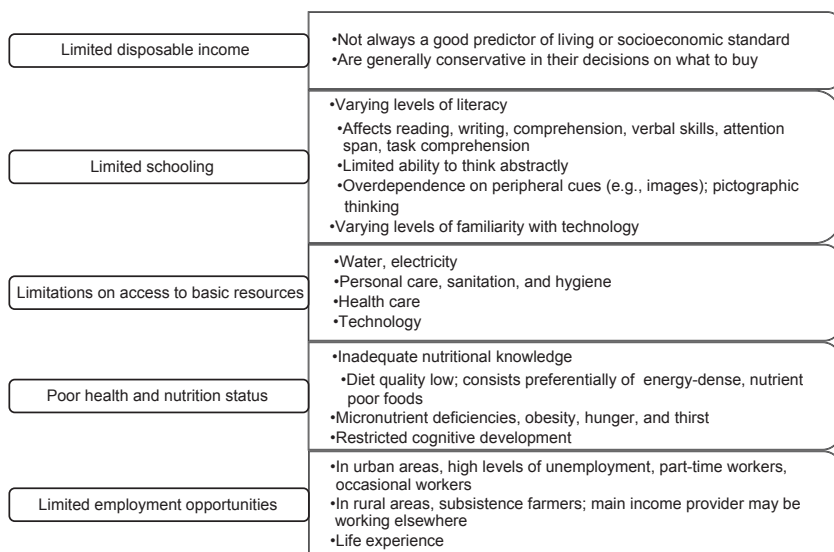


FIGURE 15.1 Characteristics of adult consumers in low-income populations that may influence the design of consumer research studies.

position is complex. [Howe et al. \(2012\)](#) reviewed the strengths and limitations of various indicators and concluded that no single measure will be ideal for all studies and contexts. For recruiting and screening of research participants, the selection of a tool will depend on the specific research question. In some countries, disposable income of an individual or household at a specific time is not necessarily a good predictor of living or socioeconomic standard. Examples are families of migrant workers that live and work in one region and distribute money and goods to the household in another region/country, or households, especially in rural areas of developing countries, that are to an extent self-sufficient owing to farming and food production activities providing a major part of their food requirements.

For low-income consumers, making choices about foods is complicated by economic constraints, limited schooling leading to low literacy standards, inadequate nutritional knowledge, and other psychological factors ([Singh & Kathuria, 2016](#)). For them, food purchases commonly constitute a very large percentage of disposable income, especially for those in urban areas ([Chase et al., 2003](#)). For this reason, such consumers are generally conservative in their food choice decisions and are conscious of buying poor-quality products or products of inconsistent quality. However, because of the constraints mentioned, such individuals often purchase low-quality, unhealthy, and unbranded food ([Ali, Kapoor, & Moorthy, 2010](#)).

Low socioeconomic status does not necessarily equate to low intelligence. Intelligence is the result of genetic traits transferred from parents and engagement with the environment wherein individuals develop and operate. Sadly, consumers from low socioeconomic backgrounds often lack the opportunities of high-level schooling, which may lead to lower literacy and limited access or lower familiarity with technologies (e.g., computers, Internet, social and other media) compared to the norm in more advanced socioeconomic classes. According to [Carstens \(2004\)](#), literate consumers have developed skills that help them to understand written text. These include perception skills (the ability to discriminate between letters, words, numbers, pictures, or whatever is on a page), decoding skills (the ability to recognize words), encoding skills (the ability to comprehend information), feedback skills (ability to think about information), and memory skills. Thus, consumers with low literacy levels have limited ability to find and manipulate text and numbers to accomplish complicated related tasks, e.g., associate price, weight, and description of a product in a buying context ([Adkins & Ozanne, 2005](#)). There is a lack of research comparing the performance of adult consumers with varying literacy levels in evaluating food products and translating perceptions and opinions as required in typical sensory and consumer tests. [Guinard \(2001\)](#) reviewed sensory testing with young children. Limitations in the cognitive abilities of children pertinent to sensory testing include limited verbal skills, short attention span, and difficulties in task comprehension. A fair assumption would be that similar limitations would also be present in low-literate adult consumers. However, the life experience and

physiological development of adults compared to children imply that direct application of methods suitable for children may not be sufficient.

Some insights may be gained from marketing research literature focusing on low-literate consumers. [Jae and DelVecchio \(2004\)](#) reported that in a buying situation (e.g., for food in a store), decision-making by consumers that are low literate may be affected by overdependence on peripheral cues (e.g., image on the packaging of the product) leading to poor choices. [Viswanathan, Torelli, Xia, and Gau \(2009\)](#) used the term “pictographic thinking” to express how low-literate consumers depended more on perceptual, rather than conceptual, processes, in acquiring, retaining, and using information. The physical representation of an object attracted more attention than a written representation. As an example, [Adkins & Ozanne \(2005\)](#) found that low-literate consumers tend to visualize the quantity of products to buy by picturing them, rather than using available symbolic information, such as weight or volume or units of measurement. [Viswanathan et al. \(2009\)](#) characterized low-literate consumers as persons with a lack of or limited ability to think abstractly.

Many studies have shown that low socioeconomic status is correlated with poor health and nutrition status. [Darmon and Drewnowski \(2008\)](#) reviewed studies that showed that diet quality follows a socioeconomic gradient. Consumers with greater affluence reported higher-quality diets, while persons of lower socioeconomic status and more limited economic means generally consumed more energy-dense, nutrient-poor diets. Access to water, sanitation, and hygiene is important for human health and well-being ([Jordanova, Cronk, Obando, & Medina, 2015](#)). These basic human needs are yet to be fully achieved in low- and middle-income countries. Unsanitary conditions lead to retardation of mental and social development in children, affecting IQ, school achievement levels, working memory, and behavior.

3. PLANNING, DESIGN, AND EXECUTION OF PRODUCT TESTS WITH CONSUMERS OF LOW SOCIOECONOMIC STATUS

Consumer sensory testing makes use of untrained users/likers or potential users of a product. The consumers are asked to express their liking or preference for a product using hedonic or other scales or preference indicators. Consumer sensory testing generally follows six basic steps, namely:

- Step 1: identify the question(s) that needs to be answered.
- Step 2: decide on the objective(s) of the consumer test.
- Step 3: decide on the test conditions (test participants, test location, test methods, and test samples).
- Step 4: run the test.
- Step 5: analyze the test results.
- Step 6: take action.

There are few published studies on methodology specifically designed and validated to measure food acceptability among low-income populations (Sosa & Hough, 2006). The reader is encouraged to refer to the *ASTM International Consumer Product Testing Across Cultures and Countries* manual (ASTM, 2007), which comprehensively discusses the regional, dietary, social, political, economic, religious, cultural, and language differences that should be considered when doing research in diverse market settings in low-, medium-, and high-income countries.

3.1 Step 1: Identify the Question(s) That Needs to Be Answered

Before commencing a study with low-income consumers, it is very important to understand the question that needs to be answered. The purpose of step 1 is to find out:

- *What* needs to be investigated? *Why* is the investigation necessary or why is the question important?

Some examples of published studies with low-income consumers include determining the acceptability of food aid type interventions (Sosa & Hough, 2006; Sosa et al., 2008) and product development and product reformulation for nutritional optimization (Kayitesi, Duodu, Minnaar, & de Kock, 2010; Muoki, de Kock, & Emmambux, 2012; Muoki, Kinnear, Emmambux, & de Kock, 2015). Singh and Kathuria (2016) investigated drivers of branded food choice in India.

- *What* is the nature of the test material? *How* and *when* is the test material normally used/consumed? *Who* uses the test material? *Where* is the target consumer market located? *What* is their social status, income level, language of communication, and education level?

Qualitative research methods including observation studies, interviews with key informants, and informal and formal discussions (e.g., focus groups) are useful to gain insight for planning purposes. For example, Buttorff, Trujillo, Diez-canseco, Bernabe-ortiz, and Miranda (2015) used formative qualitative interviews to identify suitable test sample menus for a study to understand preferences for items prepared by government-supported food vendors serving low-income consumers in Peru. To avoid mistakes, it may be wise to include, as part of the research team, an agent or community leader that is familiar with the social and economic structure of the particular community. Low-income consumers may be suspicious about the reasons for conducting product tests and the need to obtain their input. This has to be explained very clearly and honestly. A trusted community leader or tribal chief may play a vital role in explaining the reasons for the need for consumers' involvement in a particular project.

Nkhabutlane (2014) reported a study conducted in Lesotho to investigate local culinary practices and consumer acceptance of Basotho traditional bread.

After the tribal chiefs in different regions were informed of the objectives of the research, the chiefs granted permission for the researcher to obtain access to consumers in villages. In the community the chief plays the role of gatekeeper to ensure that the rights of consumers are not violated. The researcher explained that for this process it was an advantage that she was a Mosotho (resident of Lesotho) woman familiar with the culture and language. The chiefs as well as the nutrition extension officers operating in the various regions were valuable partners for recruitment of participants and for arranging meetings and meeting places. In a preliminary phase of the study, the researcher used a questionnaire, to obtain a better understanding of culinary practices related to the products, and focus groups with women who were identified as well informed and skillful in traditional bread making. The participants also demonstrated bread-making practices. The insights gained were used to plan the subsequent standardization of bread types and a consumer acceptance study. The answers to these questions would help researchers to make wise decisions regarding the methodology and approaches to use. Thorough planning is key to project success. This includes aspects like recruitment strategies, compensation for test participation, incentives, etc.

3.2 Step 2: Decide on the Objective(s) for the Consumer Test

It is important that the objective of any consumer study is clearly defined in advance and that the experiment and the measuring criteria and instruments are carefully designed.

3.3 Step 3: Decide on the Test Conditions

While consumer sensory research is easy in its principles, its implementation at the ground level with consumers of low income/low socioeconomic status is often complicated because of varying education and literacy levels (Muhimbula, Issa-Zacharia, & Kinabo, 2011). The question to ask is, can we use the same standard consumer test methods, environments, and test sample setup with consumers of varying socioeconomic status? If not, what adaptations are needed?

The conventional way of conducting consumer tests with adults is to invite a group of consumers, representative of an a priori defined consumer market, to a sensory laboratory or central location for the test. On arrival, the consumers are seated individually at a table and given a sheet with written instructions explaining the procedure to follow. Consumers receive products to evaluate using some or all of their senses. Food product evaluation usually includes tasting or consumption of the food samples. Responses are recorded on the paper sheet using a pen by selecting between options, marking on scales, or writing scores. Consumers may also be asked to write comments to explain their opinions and experiences. The same procedure is also frequently conducted via devices such as computers, tablets, or mobile phones, which eliminate the use of

paper and pen. In most cases, some form of reading or writing (or typing of text) is required. Consumer tests are also conducted at home with limited contact between test administrator and participant.

In this scenario, the ability to read and to write independently is considered a given. However, the writing task is a complex organization of patterns of high mental processing that can embrace all types of thinking (word decoding and reading comprehension), judging, imagining, reasoning, and problem solving (Hoover & Gough, 1990). To understand written instructions, a reader has to be able to read the written instructions first (Rue, 1990), which requires a proper reading level from the participants. The following sections will give some perspective of factors that need to be considered when planning a consumer sensory test with low-income populations and/or low literacy levels.

3.3.1 Test Participants

For consumer testing, participants are usually selected based on criteria such as age, gender, socioeconomic group, specific geographic location, culture or ethnic group, association with the product category, etc. The number of participants required is determined by the need to have statistical confidence in the results. Before planning any sensory test with consumers, it is important to set criteria for the expected level of education and/or literacy and standard of living of the individuals that will form the group of respondents or participants. Consumers in general, but low-income consumers in particular, do not like to reveal their income and if asked may not necessarily be honest about it. It may be more appropriate to use other, indirect indicators of socioeconomic position (Howe et al., 2012) when recruiting consumers for income-related consumer research. As an example, in Argentina Sosa and Hough (2006) used the type of school (private or public) where families sent their children as a more objective indication of income level, rather than asking the income question directly. Other indicators of income level may be the area where consumers reside, type of employment engaged in, areas where shopping is done, etc.

Prerecruitment of consumers in low-income communities is best done through reliable local field agents familiar with the societal structure, culture, and communication strategies that work in the area (word of mouth, social media, established regular meetings, etc.). The field agents should be well trained and should understand the nature and the purpose of the research. In low socioeconomic markets, selection for test participation may be considered an achievement. Communication to explain the reasons a particular person does not qualify to participate should be handled with skill and consideration. Our experience has been that low-income consumers feel more comfortable attending events as part of a group and prefer to follow the direction of a community leader. Involvement and briefing of community leaders or service agents (e.g.,

staff at the nursing clinic, teachers, social care staff, church or community group organizations) to assist with the identification of suitable candidates may be useful. Consumers may need to be reminded of the date, time, and location for a consumer test.

3.3.2 Test Methods

This section will focus on the two general classes of consumer test methods. For acceptance tests, consumers are presented with products, all at once or one by one. For each product a hedonic response is elicited, typically using a scale to quantify overall acceptability or acceptance of a particular characteristic (Hein, Jaeger, Carr, & Delahunty, 2008). Acceptance methods measure the degree to which a product is liked or disliked and give interval or ratio data. Preference test methods require the selection of one product that is preferred over another (Lawless & Heymann, 2010). Preference methods (paired comparison, ranking) produce ordinal data that permit the identification of sample preference within the test set.

3.3.2.1 Preference Test Methods

Coetzee and Taylor (1996) developed a paired comparison method for illiterate and semiliterate consumers whereby the usual three-digit sample codes were replaced with graphic symbols. They found the usual three-digit number codes ineffective because illiterate consumers struggled to read and interpret the numbers on the score sheet (limited numeracy). The researchers found that for low-literate consumers, codes consisting of the same symbol/shape but with different pattern fills worked best for sample identification. It was concluded that the majority of the consumers, who could not read or write, could reliably perform this type of paired comparison test when clear verbal instructions were given. The researchers reported that consumers were able to perform or complete the test without any assistance when using the adapted score sheets. Only occasional direction was needed to explain to participants how to perform the test.

Coetzee (2001) later proposed an adapted paired preference test method (Fig. 15.2) to understand the opinions of illiterate and semiliterate consumers. Consumers were given two food samples and asked to make a choice based on some specified criterion or characteristic. The samples were coded with colored stickers. Within a set, the stickers had the same shape (e.g., circles) but different colors. Consumers were given a blank paper and two stickers corresponding to the sample coding stickers. After tasting the products, consumers were instructed by the test administrator to select the sticker corresponding to the one on the selected sample and to paste the sticker on the blank paper to indicate their choice. With this adaptation, the use of a pen for filling the form was avoided. The presence of a pen as a writing instrument adds stress for a person with limited writing proficiency.

Joseph Kamdem developed the Kamdem paired preference test for use with low-income, low-literate consumers (Kamdem Mademgne, 2016). The method

Which of these samples do you like the most? ☐ ☐

Stickers

Thank you!!!!

FIGURE 15.2 Score sheet for the adapted paired preference method proposed by Coetzee (2001).

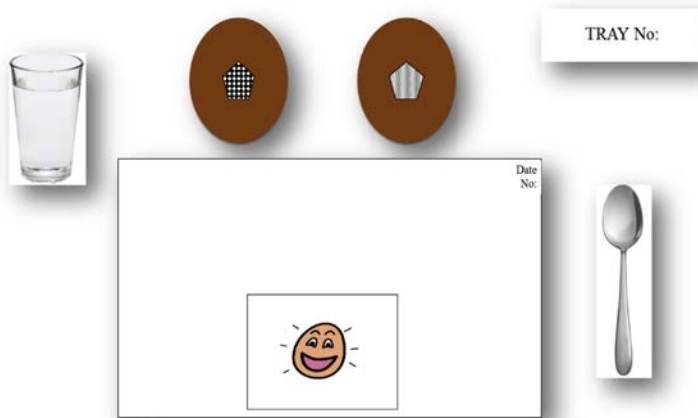


FIGURE 15.3 Example of the presentation of the serving tray for the Kamdem paired preference test.

is the result of ongoing research intended to develop consumer sensory test methods for consumers with low literacy levels applicable in developing countries. The objective is to design practical methods to be used in low to fairly low technology situations requiring no or limited assistance from test administrators. Ideally, a researcher should be able to use the methods in a remote rural village. With the Kamdem method, the efficiency of the paired preference method for use by low-literate consumers was improved to an extent that almost no assistance was needed.

The Kamdem paired preference test (Fig. 15.3) comprises the following:

- Two product samples are presented on a serving tray with suitable utensils and rinsing agent.
- The product samples are coded with the same symbol/shape but with different pattern fills. Codes are printed on stickers and placed on the samples for identification within a set.

- A white sheet with a positive smiling face displayed in a rectangular block in the center of the sheet is provided.
- A series of pictorial instructions is displayed on a poster (Fig. 15.4) along with the playing of prerecorded audio test instructions, for example, “Please listen carefully. You have been given two biscuits. First taste one biscuit, then drink some water, then taste the second biscuit. Which one of the biscuits do you prefer? Remove the sticker of the biscuit you prefer and paste it on the smiley face on the white paper.” The instructions are to remove the code sticker from the sample chosen and to stick it on the positive smiling face (no reading or writing task is required).

Compared to running the paired preference test in the more conventional format, i.e., with written instructions, using a pen to mark choice, or with interview-style instructions, the Kamdem paired preference method:

- allowed a far larger number of low-literate consumers (82% but still not all) to complete the task independently;
- needed fewer assistants to run the test;
- allowed faster completion of the task by low-literate consumers;
- was perceived by more low-literate consumers as easy to follow, and assistants also judged consumers as more confident when performing the task.

No published studies with low-income consumers applying a ranking method to evaluate food products were found. However, a method was developed by Birch in 1979, named ranking by elimination, and applied by Léon, Couronne, Marcuz, & Köster (1999) and Liem and Mennella (2003) using young children as participants. They found good repeatability for children older than 5 years. The test method was considered quite easy, thus during the test only verbal instructions were given. Children tasted five types of biscuits following the instruction: “I want you to taste the five biscuits in front of you and to show me the one you like the most.” The child was invited to finish the favorite biscuit. After that, the child tasted the four remaining biscuits again and showed the one he or she preferred. This favorite biscuit was then also eaten or, if the child did not want to eat it, eliminated from the choice set. The process was repeated until all the biscuits were ranked. The method was found to be successful and good repeatability was observed. The method could potentially be applied with low-literate and semiliterate adult consumers.

3.3.2.2 Acceptance Test Methods

Food acceptance testing aims to identify different forms of behavior toward food products. Lim (2011) provided a systematic comparison of different hedonic scaling methods with the view of helping researchers in selecting the most appropriate method for a specific requirement. A few studies have focused on research to optimize hedonic scaling methodology for use with low-income consumers.



FIGURE 15.4 Pictorial instructions used to describe the steps for completing the Kamdem paired preference test. Pictures 1 to 8 were presented vertically on a poster in order of the test evolution. Note that the coding symbols used for the pictorial instructions were different from what was presented to consumers.

Curia, Hough, Martínez, and Margalef (2001) found that the popular 9-point hedonic scale (Peryam & Pilgrim, 1957) anchored with Spanish phrases, translated from English, was not appropriate for low-income consumers from rural areas in Argentina. The research demonstrated that 30% of the subjects ranked the translated phrases differently in relation to the English version. The authors recommended the use of numbered or unstructured scales for low-income consumers in Argentina. Further, the use of the 9-point hedonic scale in languages different from English should be done with caution, and researchers need to make sure that participants understand the scale phrases in a similar manner.

For studies with illiterate or semilliterate consumers in South Africa, Coetzee (2001) proposed an adapted five faces hedonic test. Consumers were verbally instructed to remove and stick the coding sticker on the corresponding face to indicate level of liking of a sample. Low-literate consumers reacted positively to the adapted method. It was emphasized that the consumers could not handle more than two samples per test. Serrem, de Kock, and Taylor (2011) used a similar face scale (Fig. 15.5) with children (7–8 years of age) to determine the acceptability of nutritionally optimized biscuits over an extended period of consumption. For another study with low-literate consumers in South Africa, De Bruin and Minnaar (1994) combined a 5-point facial hedonic scale with numbers 1–5. In that study, low-literate participants received coded samples, tasted them, and then pointed to or selected on the scale the face that best represented how much each sample was liked or disliked. An assistant recorded the selection of each respondent. The authors concluded that the specific test method used, together with the assistance given to assessors during evaluation, led to successful completion of the task and credible results.

Bwabale, Moyer, Komakech, Wabwire-Mangen, and Lori (2013), working with illiterate women in a rural area of Uganda, implemented a novel survey technique using 10 local beads as tools of measurement. The research team worked with the local population to identify the type of local beads to use. Objects of measurement could be seeds, stones, or beads, but should be appropriate and culturally accepted. The survey required participants to use the beads to indicate their households' expenditure on foods, health, education, and other items. The same tool was used to measure how strongly the women felt about

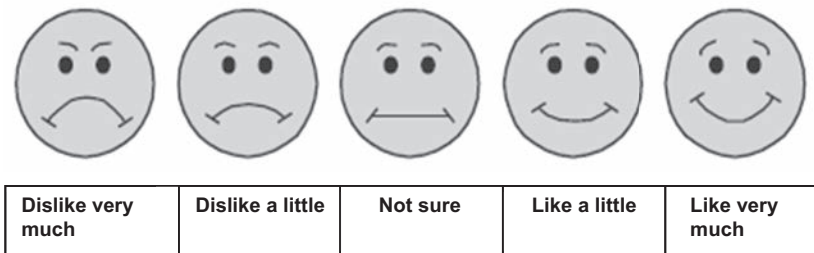


FIGURE 15.5 Five faces hedonic scale used with children in South Africa (Serrem et al., 2011).

concepts. The illiterate women could readily create piles of beads to indicate responses. Researcher could easily convert the number of beads into a scale range. They concluded that the 10-beads method was a feasible approach for use with illiterate consumers. The technique provides an example of how locally adapted social research methods might be used effectively in community or household surveys with illiterate or low-literate participants. For measuring sensory acceptability among low-income populations (Sosa et al., 2008) used a simple universal scoring number scale: consumers were instructed to score (from 1 to 10) samples. It was argued that such a scale is familiar to consumers in many countries.

Working with low-income consumers, Van Oirschot and Tomlins (2002) emphasized that the phrasing of questions is paramount. Questions must be clear and easily understood by the consumer. They gave a classic example “how much do you like” is not the same as “how much do you eat,” because consumption is influenced by many factors (e.g., price, availability, whether the consumer is on a diet or restricting intake for specific reasons).

3.3.3 Test Locations

The effects of tests with low-income consumers being conducted in different locations, such as a laboratory, a central location, or the home, has not been explored much in research (Sosa & Hough, 2006). For low-income consumers, central location test venues close to home, work, or recreation areas seem to work best. Preferably, the test venue should be familiar to the target consumers. It may be necessary to organize transport to and from the test venue if it is not convenient for consumers to reach or if the affordability of public or other transport will prevent consumers from making the effort to attend. Community centers, recreational or other gathering areas, classrooms at schools, shopping areas, or the homes of consumers are all venues to consider.

The test station should preferably, or as far as possible, be neutral in terms of odor, sound, and visual stimuli (graphics and advertising) that may divert the attention of the participants. Plan and design a basic and clean testing area where a consumer can focus on the main task. Low-literate consumers are even more easily distracted by images and visual objects in an environment. The distance between test stations must be considerably large to avoid any interference or copying. However, modern consumer research thinking often emphasizes the need for test locations that represent the environment where the food products are usually selected or consumed. If this is the focus, then research teams must plan accordingly.

Sosa et al. (2008) compared two locations (home and central location) for measuring the acceptance of two chocolate milks and two soups with low-income households. Samples received higher scores in the home than in the central location. In the central location, consumers were more critical than in the home location test. It was concluded that if product acceptability discrimination is of interest, the central location test would be more adequate for low-income

populations. Tomlins (2013) showed that urban low-income consumers in Uganda gave more varied responses to different types of orange-fleshed sweet potatoes than rural consumers.

3.3.3.1 Security

In some low socioeconomic regions, crime and violence may be a potential risk. The personal safety of test administrators and participants and the security of equipment have to be considered at all times and security measures may need to be organized.

3.3.3.2 Electricity, Water, Restroom Facilities, Equipment, and Furniture

For effective planning, it is always good to be thoroughly familiar with the setup and resources available at the venue. If possible, visit the venue well in advance and compile checklists of everything that is/is not available and that will be needed during the test. Consumer research can and may need to be conducted in a very basic room or shelter setup or even outside, but when food is to be consumed, provision for hygienic handling of test samples and consumption is of utmost importance.

In low-income settings access to restrooms and washing facilities may be limited. Make provision for washing facilities with water and soap to clean hands before handling and consumption of food products. Buckets with water or “wet wipes” may serve the purpose.

3.3.4 Test Samples

In all consumer tests, the same general good sensory practices (Lawless & Heymann, 2010) need to be applied. For low-income consumers it may be important to serve samples for evaluation in the format and type of containers that the group is familiar with. For example, Van Oirschot and Tomlins (2002) mentioned the use of orange bowls for serving traditional cassava products in Tanzania. The bowls were described as a familiar standard for Tanzanian consumers. The same authors motivated the decision to test the cassava products without a sauce first and then with a sauce. They explained that Tanzanians would never eat their *ugali* without a sauce. For sensory evaluation purposes, however, the researchers were particularly interested in the quality of the base product without the distracting potential of the sauce.

Dividing a simple paper plate in four using a marker to serve and identify four different samples, as was demonstrated by Tomlins (2013), is both a practical and an economical way to serve samples.

Our experience has been that consumers from low-income environments may arrive at the test feeling very hungry and/or thirsty. It is not unusual for respondents to eat all the samples before attending to or answering any of the questions. Hunger or thirst may lead to overvaluing of products or product

characteristics (McCrickerd & Yeomans, 2015) and lower discrimination ability. To avoid this situation, it may be necessary to first explain and/or demonstrate the instructions for the test before serving the samples. It may also be a good idea to first offer some water to drink to quench severe thirst and/or offer a small bland tasting snack to compensate for severe hunger.

3.4 Step 4: Run the Test—What to Expect

In some ways a consumer test with low-income consumers is no different from similar tests with consumers from a higher income population. The same difficulties, e.g., consumers arriving late, consumers not arriving, may be experienced.

Informal communication structures, e.g., word-of-mouth sharing of information, perceptions, and opinions, are often very strongly grounded in low socioeconomic societies. News of a food product test and especially the promise of some form of compensation may spread very quickly and soon potential participants may be very keen and sometimes even insistent on signing up for the test, sometimes for the wrong reasons (e.g., expectations of relief of hunger, financial or in-kind reward or gain, relief from boredom by social interaction). The research team should be prepared for “test crashers” although “on the spot” recruitment of consumers may be a valuable source of test participants in certain circumstances.

If a low-literate consumer does not understand what is expected of him or her in a product test, how would he or she be able to give responses that are accurate and reliable? Consumers with a low-literacy level may not be able to complete evaluation procedures independently. In such cases one-on-one interview-style sessions may be much more appropriate. In situations in which consumers are more comfortable with a vernacular other than what the researcher can handle, provision for translation or interviewers that speak the language of comfortable communication may be required.

Consumers who are not sure of what they need to do may feel very vulnerable. Uncertainty of the task requirements may be embarrassing to consumers. Under such circumstances, consumers will use various coping strategies to try to hide the fact that they are unsure or not at ease with the situation. The behavior may range from complete avoidance of such test-like situations to copying the actions of others, leaving questionnaires blank, or using various indiscriminant excuses or explanations to leave the test, e.g., faking disabilities “I did not bring my glasses and cannot see to read the instructions” or “My doctor said I should not eat this type of product.”

When consumers ask for assistance or assistants offer to help consumers, there is a good chance that the assistants may subconsciously influence responses, which may compromise the research. Thorough training of assistants and interviewers is an important requirement for successful completion of consumer tests with low-income consumers.

3.4.1 Time

Consumer tests with low-income consumers may take longer to complete. Enough time should be planned to provide clear instructions or demonstrations, for consumers to read or listen to instructions. Consumers from lower social classes with low or no formal education are generally less “test literate” and will take more time to understand and follow instructions. In parts of Africa and elsewhere there is a cultural tendency toward a more relaxed outlook on time, which may mean that consumers may arrive for a test later or earlier than the scheduled time.

3.4.2 Transport

Income limitations of the target group of participants may have a direct impact on test planning. It may be necessary to arrange or provide transportation to and from the test venue or select a venue that is easily accessible for participants. Scheduling a suitable time of day for the consumer interaction also needs prior consideration. Jobless or job-seeking consumers are often very eager to participate in consumer tests during the day, especially if there is the added bonus of an incentive.

3.4.3 Test Administrators and Assistants

The test coordinator should clearly understand the objective of the test and the alignment with the consumer group and context. Verbal and written proficiency of the test participants is a very important aspect to consider. When literacy levels are low, personal interviews rather than self-administered tests are often more appropriate. This may imply that more staff are necessary or that more scheduled time for the test is needed with associated higher cost. If used, test administrators should be well briefed and trained. It is their duty to make the participants feel comfortable enough to express true and honest opinions. An option that has worked well in southern Africa is to train students who grew up in the community or who are familiar with similar communities to ask the questions and mark the forms.

The interviewers should:

- be familiar with cultural issues such as social etiquette that may be extremely important in the context (e.g., manner of greeting);
- allow adequate time and have patience when explaining procedures;
- use appropriate language and words to allow for complete understanding by the consumer group without leading; to ensure reliable and valid results, the interviewers should not speak down to the participants or appear or behave authoritative (e.g., in the choice of apparel to wear or body language);
- speak the vernacular of the participants, which is often essential and of much value.

3.4.4 *Incentives and Rewards*

What is appropriate as compensation or incentive for test participation? In Argentina, [Sosa and Hough \(2006\)](#) presented subjects with a bag of food products as recognition for their time and effort. We have used cash, store gift vouchers, and products as gifts. The value and type of incentive provided should be aligned with ethical, cultural, and situational norms. [Nkhabutlane \(2014\)](#) mentioned that money exceeds other types of incentives because its value is easily translated and understood by consumers.

3.5 Step 5: Analyze the Test Results

Irrespective of the consumer market, there will be no difference in the need for statistical analysis of the data. Fortunately, commercial statistical packages for data analysis have become more accessible for a greater number of researchers in developing and low- and middle-income countries ([Van Oirschot & Tomlins, 2002](#)).

3.6 Step 6: Take Action

The last step of any consumer test is to interpret the findings by reverting back to the original question (step 1); considering the test objective (step 2); taking into account the conditions of the test (step 3), how the test was run (step 4), and the methods used to analyze the results (step 5); and making a final conclusion and recommendation.

4. CONCLUSIONS

Incorrect business or policy decisions about products and opportunities may be made because conventional consumer sensory methods are not able to reliably measure the opinions of consumers in low socioeconomic environments. An important reason is that these methods take literacy and language capabilities for granted.

Little is known about how traditional measuring approaches can be used to collect valid and objective data in communities where literacy rates are low. There are opportunities for more research to optimize current and develop new methods to measure food acceptability and food preferences of consumers of low socioeconomic status. Research with methods such as the 10-beads method and Kamdem paired preference test should be tried with other products, with other cultural groups, and in different social or context settings. There are many opportunities to adapt other traditional sensory and consumer test methods in similar ways. Scientists in developing countries will be the most suitable for taking on this task. Support for training of scientists and practitioners in sensory and consumer science should be prioritized in these regions.

5. FUTURE TRENDS

Methods suitable for use with low-literate consumers may also present solutions for use with other consumer groups, e.g., children or physically or mentally challenged consumers, among which reading and writing skills may be limited. Another area of application is cross-cultural/cross-language research in which consumers are functionally literate but where methods that are less dependent on language literacy are desired. Such methods would eliminate the need to translate questionnaires and scale category descriptions into multiple languages, which may save time and effort. While the Kamdem paired preference method still makes use of audio instructions, which are therefore not completely language free, further research should investigate the use of video or animated instructions.

The use of implicit measures such as facial reading could be an option for understanding low-literate and low-income consumers. Erickson, Drevets, and Schulkin (2003) mentioned that facial expression showing emotion and social interaction is a fundamental way of understanding illiterate behavior. However, no research on facial expression of low-income adult consumers or adults with low-literacy levels could be found. Danner, Sidorkina, Joechl, and Duerrschmid (2014) presented an approach to facial reading capable of analyzing facial expression patterns from video data. They concluded that the technology was sufficiently accurate to detect significant differences in facial expressions elicited by different orange juice samples and can deliver additional information to conventional acceptance tests.

These are some of the areas that could be pursued for future sensory and consumer research with low-income and low-literate consumers.

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Part V

Consumer Research With Non-food Products

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Chapter 16

Cosmetic Products

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Chapter Outline

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Industrial actors in the beauty and health sectors are constantly proposing innovations, either for maintaining a competitive advantage or for regulatory reasons, the latter being more and more constraining for manufacturers. By using active ingredients that are always more efficient and more targeted, cosmetics manufacturers offer new textures, new fragrances, or innovative surface aspects to consumers. These sensory innovations provide new sensations, increased comfort in usage, but, most of all, they are inseparable from product efficacy perceived by consumers: a texture that is too liquid, a color that is not intense enough, or a fragrance that is too strong are sensory features that will convey, sometimes even unconsciously, a lack of efficacy of the products.

It is thus key for cosmetics manufacturers to understand, at the earliest stage of development of their products, what the key expected benefits are for consumers and which sensory features drive liking and choice, but also perceived efficacy.

Before going further in the overview of the specific features of testing cosmetic products with consumers, it is necessary to mention the latest definition of a “cosmetic product” as agreed on by authorities in most countries.

For instance, Article 2 of the EU Cosmetics Regulation [Regulation (EC) No. 1223/2009] incorporates the following definition of a cosmetic product: “a ‘cosmetic product’ shall mean any substance or mixture intended to be placed in contact with the various external parts of the human body (epidermis, hair system, nails, lips and external genital organs) or with the teeth and the mucous membranes of the oral cavity with a view exclusively or mainly to cleaning them, perfuming them, changing their appearance and/or correcting body odors and/or protecting them or keeping them in good condition.” Among the products included in this definition are skin moisturizers, perfumes, lipsticks, fingernail polishes, eye and facial makeup preparations, cleansing shampoos, permanent wave products, hair colors, and deodorants, as well as any substance intended for use as a component of a cosmetic product. Fig. 16.1 illustrates the various categories of cosmetics and personal care products (Cosmetics Europe, 2016).

When testing these different products with consumers, several elements should be considered because they are specific to cosmetic products. Indeed the nature of these products, the way to use them, and the effects they have on

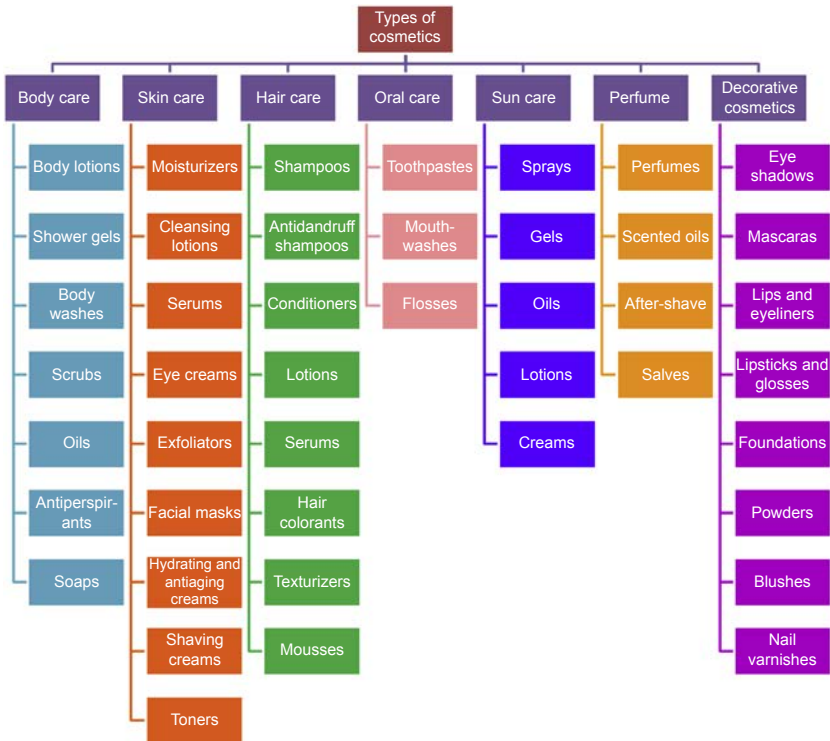


FIGURE 16.1 The seven categories of cosmetics and personal care products according to Cosmetics Europe. Adapted from Cosmetics Europe. <https://www.cosmeticseurope.eu>.

the application areas of the body make them particular and should be taken into account in the design of consumer studies in which end users are required to use and apply them before giving their opinion on them.

This chapter focuses on specific factors related to testing cosmetic products with consumers regarding the target end users included in these studies or the experimental design of the tests or the criteria and stages of evaluation. These factors are considered in comparison to testing food products with consumers. They highlight how much sensory analysis and especially consumer tests have to be adapted to cosmetics' peculiarities to provide relevant outputs on products and gain relevant insights into consumers.

1. CONSUMER TARGET

1.1 Considerations on Skin and Hair

Cosmetic products offered today are categorized in such a way that consumers who want to purchase a cream, a shampoo, or a foundation face a very segmented market according to hair or skin criteria, but also to end benefits and consumer needs. For example, a woman with normal hair will be “implicitly” recommended to use a shampoo for normal hair and will have to choose between products providing shine, or giving more strength, or preventing oiliness, or providing care and protection.

Thus, end consumers are often recruited in consumer tests according to their skin or hair type. Most of the time, respondents are asked to declare what they think the nature of their skin is (very dry/dry/normal/mixed/oily/very oily) or in the case of hair products the nature of their hair (normal/dry/oily/oily roots and dry ends, etc.), but also the length of their hair. For deodorants, the usual level of perspiration can also be taken into account. Consumer studies tend to show that quite often there is a gap between what consumers think they have and declare and the real nature of their skin or hair. But most of the time no diagnosis is necessary at the recruitment stage, neither by a hairdresser, a beautician, nor a dermatologist, because the objective of such a screening is to select potential users of the products to be tested. Thus, a woman who thinks she has normal hair will buy a shampoo for normal hair even though her hair is dry in reality.

These are examples showing that the recruitment of consumers in cosmetic tests is much more specific than in most food products studies. But they also highlight the fact that there is a high variability between consumers in terms of skin or hair. For instance, a study on a mask for dry and fragile hair will be carried out with usual consumers of such products. Thus, the common points of recruited respondents will be the sensitive nature of their hair as well as usage habits and other marketing aspects, but variability will remain high between long-haired and short-haired women, or those with very sensitive and not very sensitive hair, or those with colored and natural hair, etc., thus leading to variable perceived sensations on the hair after application.

Another specificity of consumer tests with cosmetics lies in the fact that for some categories it is sometimes necessary to present the product(s) to be tested to consumers at the stage of recruitment before selection for the test. Indeed, a study on a foundation will require respondents to use the product under test instead of their usual product. Thus, there must be a perfect match between each respondent's skin tone and the color of the proposed foundation. In case of mismatch, respondents will definitely not use the product in their daily life. Hence there is a specific requirement to have consumers see the product to be tested at the earliest stage of recruitment to ensure that the declared usual color of foundation and the tested color are almost identical.

To conclude, exclusion criteria must also comply with relevant legislation on cosmetic products in the considered country (for instance, and nonexhaustively, non-inclusion of pregnant women, people with allergies, those receiving medical treatment, etc.).

1.2 Professionals

Products designed for professional use are quite common in the cosmetics domain and are used in specific areas such as hair or beauty salons. The regular users of these products are thus professionals (hairdressers, beauticians, etc.) who need to be the recruited respondents in studies on these products. Of course, potential clients of these professionals can also be interviewed to collect their feedback on skin-feel or results on their hair, but the professionals' opinions are the most important in those cases because they are the users of the products. They will evaluate usage qualities as well as cosmetic performance.

2. TEST CONDITIONS

2.1 Anonymous Presentation of Products

Subjects receive products to be tested in neutral and anonymous packaging, which is common practice in sensory evaluation at an early stage of development for R&D purposes. This allows masking any recognizable signs while preserving product sensory properties.

For some liquid or fluid products like fragrances, shampoos, or conditioners, repackaging them in neutral containers can be done only if their texture and appearance are not significantly altered.

However, in cosmetics it is not rare to be confronted with difficulties in masking products. Indeed, some are inseparable from their packaging and, finally, it is the coupled product-pack that has to be considered by consumers. Then the packaging may have a special shape or size or recognizable sign that cannot be hidden, such as is the case for some lipstick tubes with specific shapes or for some mascaras with specific brushes, but also for some solar sprays with a specific dispensing system, etc. In those cases, signs allowing recognition (shape, color, logo, etc.) must be hidden as much

as possible (as emphasized in the French Standardization Association application guide on sensory analysis standards for cosmetic products; [AFNOR GA V09-027, 2012](#)).

2.2 Test Duration

The type of test to perform depends on the study objectives. In cosmetics, it is not rare to ask consumers to give a first evaluation on site to obtain feedback on the immediate perception of the products (immediate fragrance perception of a neat shower gel, for example). And then respondents take the products home for a usage test during which they will use them under natural conditions, in replacement of their usual product.

In home-use tests, if several products have to be evaluated by the same respondents, the usage duration must be the same for all products. This duration depends on the study objective, the nature of the products, and their frequency of use: for example, toothpaste can be tested over 1 week, a shampoo over 2 weeks, a moisturizing day cream over 2 weeks, an antiaging cream over 3 months, etc.

In the case of products with a long-term efficacy claim (for example, slimming, antiaging, etc.), it is interesting to ask consumers to judge the cosmetic qualities of a product after a short period of use and then to assess the perceived efficacy during the final usage at the end of the test period. For example, a deodorant can be evaluated at application and then after a 48-h period to determine subjective perceived body malodor efficacy (neutralization and masking).

When testing several products, it may be recommended to observe a break period called the “washout period” between two successive products to allow complete elimination of the effects of the first product on the application area. In that case, the time period during which no product is applied or during which the usual product is used again has to be determined.

It is also recommended to use products during the “normal” period in which they are usually used, for example, in summer for solar products or in winter for protective lip balms.

2.3 Product Presentation

In the cosmetics field, several test designs are often encountered, according to the number of products to be tested.

It is common to have consumers evaluate one product incorporated into their beauty routine, i.e., used with other products usually applied before or after the product in question. For example, a test focused on a shampoo will require consumers to apply and evaluate its usage qualities at first sight and during application as well as its cosmetic performance (“hair-feel”) on wet hair after rinsing, but it will also imply that respondents apply their usual

conditioner afterward and finally evaluate the cosmetic performance of the shampoo on dry hair. Of course, the last evaluation will be influenced by the use of the conditioner, but it allows the results on dry hair to be assessed under natural conditions.

Another common practice is to ask consumers to evaluate several products in the same test. In that case, several product presentations are possible: sequential monadic, pure monadic, or comparative (evaluation on “half-head,” “half-face,” or “half-body”) (Gagnaire & Freyssinet, 2016).

Sequential monadic evaluation is not always the most relevant approach in cosmetics because it can result in a very long total duration of the test.

Pure monadic methodology is more appropriate when testing products with a long-term effect. In that case, the different products of the test are evaluated by different paired samples of consumers, each respondent testing only one product. Ensuring homogeneous cells of consumers supposes controlling all skin or hair characteristics of the respondents on top of their usual habits and routines, which can be a challenge as described earlier under “Considerations on Skin and Hair.”

Finally, comparative evaluation is also encountered in the case of studies related to two products only. Consumers are asked to apply each product on half of their face or half of their hair, for example, trying to do it in the same way for both products. Thus, products are directly compared live. For instance, a first deodorant is applied on one armpit and a second on the other. The sides of application have to be randomized to avoid any bias due to right- or left-handed people. But this approach remains the least natural one and is not adaptable to all product categories.

In all cases the amount of product provided to respondents must be adapted to ensure an ecological evaluation. Thus, a shampoo will be supplied to consumers in different quantities according to the length of hair of each respondent, long hair needing more product than shorter.

2.4 Product Distribution

In the case of studies on more than one product, they can be distributed in different ways according to the type of test:

- Simultaneous distribution: All products are provided at the beginning of the test with the overall questionnaire. Instructions on how and when to use the products are key to ensure appropriate participation of respondents. They will include information such as the order of testing, length of use of each product, washout period, usage of extra products from the usual beauty routine, etc.
- Sequential distribution: Respondents receive the first product to be tested and its corresponding questionnaire at the beginning of the test. At the end of this first test period, they return both product and questionnaire (or validate an online questionnaire) and are provided with the second product and questionnaire and so on.

Regarding returning products back to the test organizer, this may be required for confidentiality reasons regarding tested prototypes (like in food), but in cosmetics it can also be for measurement purposes: usage of the product can be assessed by a complementary measure of consumed quantities by weighing the product before usage and after return.

3. EVALUATION FEATURES

3.1 Application of Products

When testing cosmetics, the areas of the body where products are applied are very diverse according to the type of product (Dreyfuss, 2016). For instance, application will be done:

- on the face (eye contour, lip contour, cheeks, forehead, nose, neck) when testing a foundation, a solar product, or a shaving foam, for example;
- on the eyes (eyelash, eyebrow, eyelid) when testing a mascara or an eye makeup remover, for example;
- on or in the mouth (lips, teeth, oral cavity) when testing a mouthwash or a lipstick, for example;
- on the body (neckline, bust, arms, armpits, legs, hands, feet, intimate areas) when testing a body milk, a shower gel, or a depilatory cream, for example;
- on the head (hair, scalp) when testing a shampoo or a hair coloring product, for example;
- on the nails or skin when testing a nail polish or a bleaching product for skin hair, for example.

In practice, the application of products can be observed on areas that are easier to reach than natural ones, especially in the case of a fragrance evaluation or when assessing the color of a product (for example, application on the back of the hand for a face product to evaluate its fragrance).

3.2 Evaluation of Products

3.2.1 Consumer End Benefits

Cosmetic products have the ability to provide sensations through time, from the first contact to several hours, weeks, or even months after usage in some cases. Indeed, these products interact with the body, having for some of them a long-term effect, like slimming or antiaging, which needs to be assessed after several uses on different days.

Temporality is thus inherent to cosmetic products and has to be taken into account when asking consumers to evaluate them. It is common to ask consumers to judge the product at first sight (appearance, texture, fragrance), then during application, then after removal, and finally after several units of time (minutes, hours, days, etc.).

In this respect, cosmetics developers often distinguish usage qualities of the product and its results after application, usually called cosmetic performance or “cosmeticity.”

On one hand, usage qualities relate to the behavior of the product when using it, applying it, and, in some cases, removing it. Questions asked of consumers will thus cover concepts like ease of application, satisfaction regarding quantity of foam or speed of penetration, ease of rinsing or removing, etc. Fig. 16.2 shows an example of a questionnaire designed for a consumer evaluation of mascara. Part 1 of this form includes examples of questions related to usage qualities at application.

On the other hand, cosmetic performance consists in the results of product application on the skin, hair, or body. It covers all the sensations perceived after usage (after-feel) and relate to perceived benefits (see Part 2 of the questionnaire in Fig. 16.2 for examples of questions). It is also common to interview respondents about the continuing effects or “hold” of a product like a fragrance, a deodorant, a lipstick, or a hairspray, allowing the manufacturer to claim a long-lasting performance of its product.

Moreover, the notion of perceived efficacy is predominant in cosmetics products. It is mostly associated with perceived benefits after usage of the product. It is a key question that is often used to support claim substantiation. Perceived efficacy can be inferred from answers given to questions related to after-feel and sensations perceived after usage, but it can also be directly asked to consumers in a more or less explicit way. Fig. 16.3 gives examples of statements translating perceived efficacy of a hair care product.

It is key to understand the importance of all those benefits for the end consumer and to prioritize them into different categories: the basic benefits (these must be present in the product or be provided by the product to ensure success), the drivers of performance (these are directly correlated to product performance; the more they are present the better performing the product), and the attractive benefits (factors of differentiation).

3.2.2 *Focus on Sensory Methods*

Understanding consumer end benefits can be done through several types of methodologies, both qualitative and quantitative.

3.2.2.1 *Quantitative Approaches*

Regarding quantitative approaches, home-use tests are commonly carried out in which consumers are asked to assess various criteria. However, other methods inspired from sensory analysis techniques can also be interesting for understanding consumers' perceptions of different products in a given category. Free sorting or Napping techniques give insight into usage qualities but also cosmetic performance, driving perception of a category from a consumer

Part 1: At application					
1. This mascara is... ☐ Very easy to apply ☐ Rather easy to apply ☐ Not very easy to apply ☐ Not easy to apply at all					
Please give your opinion on the application of this mascara after 1 week of use.					
This mascara...	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
2. Does not flow	☐	☐	☐	☐	☐
3. Covers eyelashes on their whole length	☐	☐	☐	☐	☐
4. Is homogeneous on the whole length	☐	☐	☐	☐	☐
5. Allows a fast make-up	☐	☐	☐	☐	☐
6. Dries quickly	☐	☐	☐	☐	☐
7. Does not make any clump	☐	☐	☐	☐	☐
The brush of this mascara...	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
8. Adheres well to eyelashes	☐	☐	☐	☐	☐
9. Is soft	☐	☐	☐	☐	☐
10. Separates well eyelashes	☐	☐	☐	☐	☐
11. Allows a precise application	☐	☐	☐	☐	☐
Part 2: After application					
Please give your opinion on the make-up result of this mascara after 1 week of use.					
This mascara...	Strongly disagree	Somewhat disagree	Neither disagree nor agree	Somewhat agree	Strongly agree
12. Is pleasant to wear	☐	☐	☐	☐	☐
13. Has a nice color	☐	☐	☐	☐	☐
14. Gives nice eyelashes	☐	☐	☐	☐	☐
15. Leaves eyelashes soft and supple	☐	☐	☐	☐	☐
16. Holds well all day long	☐	☐	☐	☐	☐
17. Gives an intense volume to eyelashes	☐	☐	☐	☐	☐

FIGURE 16.2 Extract from a product questionnaire for a mascara test.

Indicate your level of agreement to the following statements by ticking the appropriate box.				
	Totally agree	Rather agree	Rather disagree	Totally disagree
My curls are strongly shaped				
My curls are bounced				
My curls are revamped				
My curls are supple				
My curls are plumped				
My curls are not rigid				
My curls are light				
My curls hold longer				
My curls hold for 12 hours				
My curls hold for 24 hours				
Frizz is controlled during 42 hours				
My curls resist to frizzing				
My curls better resist to humidity				
My curls resist longer				
My curls stay natural				
My curls look natural				
My curls are visibly more beautiful				
My hair is soft				
My hair is silky				
My hair is shiny				
My curls are shaped without being dry				
The product is effective				

FIGURE 16.3 Extract from a product questionnaire on perceived efficacy of a hair care product.

point of view. It is, however, important to emphasize that such methods, commonly used in food, can be sometimes difficult to set up in the cosmetics field. They suppose simultaneous presentation of products for a direct comparison between them (Faye et al., 2004; Pagès, 2005). When focusing on the appearance of products or on their fragrance, this comparison can be easily performed. But as soon as we are talking about the cosmeticity of products, such as results on hair or on skin, the task becomes far more difficult to achieve or may even be impossible in some cases (half-head, half-face, or half-body study designs allow direct comparison of only two products). Artificial skins, hair swatches, or even volunteers on which products are applied can be seen as means to overcome this problem.

The external preference mapping methodology (PrefMap) (Greenhoff & MacFie, 1994) combines sensory and consumer evaluations to identify drivers of liking. This method is also a challenge in the world of cosmetic products, but in this instance for timing reasons. Performing a consumer test on a large number of products (from 8 to 15–20) can appear to take a very long time. For example, a PrefMap on 15 shampoos would suppose the usage of all the products by every respondent in sequential monadic for 1 week each, which would lead to a total length of 15 weeks minimum (and more if a washout period

is recommended between two successive products). Nevertheless, this method remains a must-have for giving formulation recommendations to formulators and for identifying ideal products from a sensory point of view.

In cosmetics it is common to create benefit maps, inspired by the PrefMap methodology. Indeed, the sensoriality of a product implicitly supports perceived efficacy. It is thus very interesting to identify sensory drivers of such a perceived efficacy. In those cases, liking is replaced by an end consumer benefit, which is thus modeled from the sensory characteristics of products assessed by trained sensory experts. The following example presents a hydration map study in which 12 facial day creams were evaluated both by a trained sensory panel and by 350 women, regular users of this type of cream. Moisturization of the face was one of the cosmetic performance criteria assessed by the consumers for every product. No large differences in hydration scores were observed between the 12 products, as seen in Fig. 16.4. On the whole, the products presented a fairly good level of hydration. Products 1 and 5 were the most hydrating creams, while products 8 and 12 were the least.

Hydration mapping was then carried out by having “hydration” as the “explained variable” in the mathematical model calculated to link perceived hydration with the sensory characteristics (usage qualities as well as cosmetic performance) of the 12 products. The regression model chosen to represent consumers’ perception of hydration was a circular one on axes 1 and 3 (see Fig. 16.5). Each virtual isocurve fits one level of hydration score and was calculated using the statistical model. Axis 1 explains most of the differences. The maximum hydration area is at the center of the map and the products with the least moisturizing effect are outside isocurve “5” in all directions.

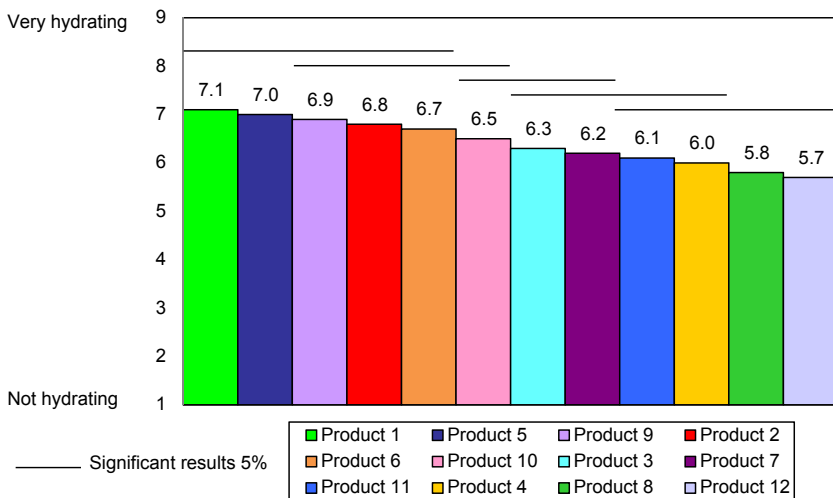


FIGURE 16.4 Average scores of perceived hydration after 2 weeks of use (three-way ANOVA; $F_{\text{product}} = 13.88$, P value $< .05$).

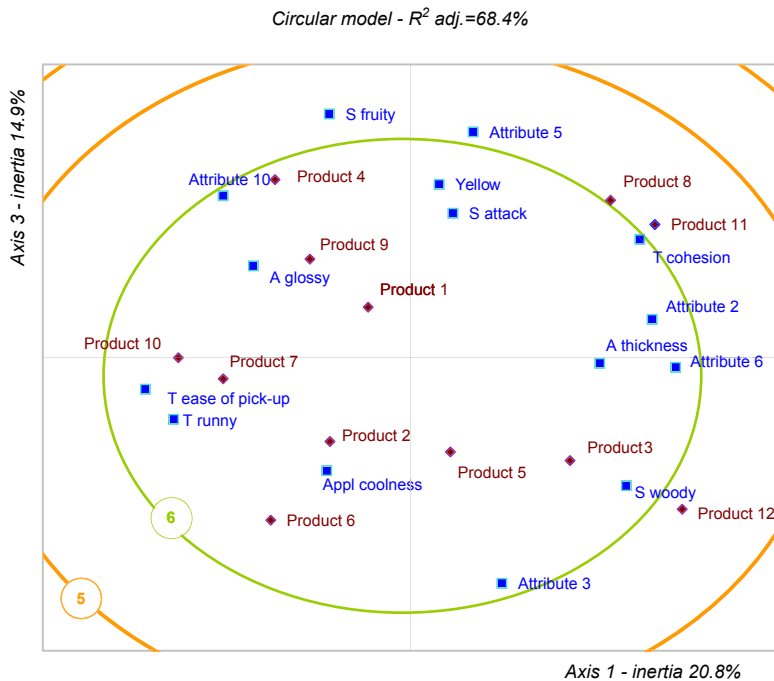


FIGURE 16.5 Hydration mapping on axes 1 and 3 (circular model with an adjusted R^2 of 68.4%).

Hydration seems to be linked with product color: the four products that were the least hydrating were yellow (products 12, 8, and 4) and orange (product 11). The most hydrating were white (products 1 and 5). This means that the presence of a yellow/orange color conveys an impression of hydration inefficacy to consumers.

In terms of texture, hydration is hardly predictable according to the texture characteristics of the creams. It also depends on the color of the cream. Indeed, the most hydrating products (products 1 and 5) and the least hydrating (products 8 and 12) presented many similar texture as well as application and after-feel characteristics:

- Regarding texture: They were rather sticky (for product 8) and moderately sticky (for products 5, 12, and 1); they were moderately easy to pick up (products 1 and 8) and not easy to pick up (products 12 and 5); they were all firm; they were moderately jellified (products 12 and 1) and not jellified (products 8 and 5), and finally they were all not fluid.
- Regarding application: They were moderately fresh (products 5 and 12) and not fresh (products 1 and 8); they were all not whitening; they were moderately greasy (products 8, 12, and 1); they were rather not sticky (products 8 and 1) and not sticky (products 12 and 5).

- Regarding after-feel: They were all not shiny; they were rather not sticky (products 8, 1, and 12), and they were not slippery (products 8, 1, and 12).

Such a study making the link between the sensoriality of products and a perceived end benefit can be used as a basis for defining optimization of formulation and allows one to gain a deep understanding of consumers' perceptions.

3.2.2.2 Qualitative Approaches

As mentioned earlier, qualitative studies can also be used to gain insight into consumer's expectations, needs, perceptions, etc. Traditional techniques, such as focus groups or semidirective face-to-face interviews, can be used, but here again special attention should be paid because of the difficulty in having products tested "live" during the discussion. When dealing with appearance, fragrance, or texture at pickup, evaluation and comparison of several products can be foreseen within the session. However, if the interest is in the application and results on skin or hair, usage of products during the session becomes impossible. It is thus common to have a preliminary experience at home with one or several products, which will then be discussed during the focus group or the interview. Consumers are asked to note and take pictures of all noticeable characteristics or events during the home experience that seem important to them, to help in the discussion and recall of memories.

4. CONCLUSION

Consumer research on cosmetic products presents some specific features mainly due to their changing nature through time and the way they interact with the human body. Temporality is inherent to scented products and also to products applied on a living surface. From the initial moment of discovery of the product until its perception after several weeks of use, a cosmetic product is actively evolving and having an impact on body perception.

Perceived efficacy of cosmetic products is also a very specific notion, which is key in the cosmetic field, in which promises made to end consumers are an important criterion of the decision to purchase. It is thus necessary to understand which sensory characteristics of a product underlie efficacy.

For all these reasons, traditional consumer approaches commonly used in food domains have to be adapted to cosmetics' particularities in a smart and agile manner.

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FURTHER READING

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Chapter 17

Consumer Evaluation of Nonfood Products

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1. INTRODUCTION

1.1 Importance of Nonfood Products in the Field of Sensory and Consumer Science

Historically linked to the food and beverage industry, sensory evaluation also applies to other fast-moving consumer goods. Because of many similarities with food, personal care products have been an important early field of application.

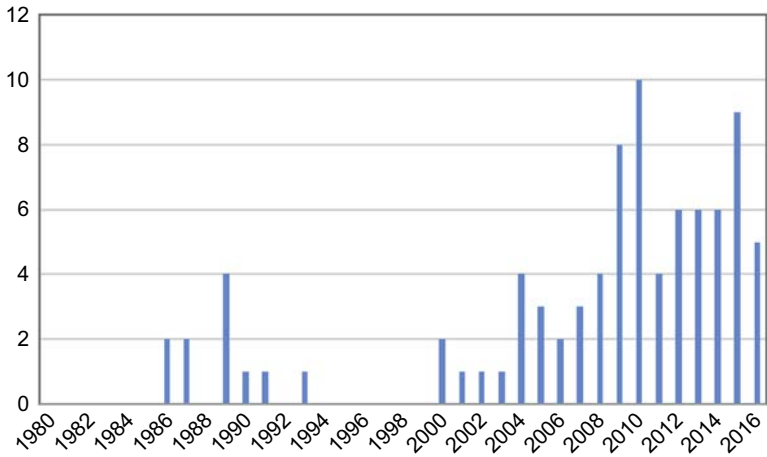


FIGURE 17.1 Evolution of the annual number of publications dedicated to nonfood studies in *Food Quality and Preference* and *Journal of Sensory Studies*.

However, sensory evaluation techniques are used to evaluate consumers’ perceptions as well as hedonic and emotional responses to many other product categories. These categories encompass a wide range of manufactured products like home care products, tobacco, textiles, sportswear and sport equipment, cars, aircraft or train amenities, cell phones, eyeglasses, etc., not to mention that within the cosmetics sector, products are extremely diverse, too (skin care, hair care, makeup, fine fragrance, deodorant, shaving cream, etc.). Analysis of the sensory science literature shows that the first studies on nonfood products were published in the mid-1980s, starting with cosmetic products. Even though the total number of publications dedicated to products other than food remains limited in the two major sensory science journals, there clearly has been a strong growing interest since the late 1990s (Fig. 17.1). As could be expected, most contributions belong to cosmetics products, but some studies have dealt with other categories (Fig. 17.2). However, most of the work applied to nonfood products is not published. As shown in Table 17.1, many sensory professionals work in relation with other industries. These “nonfood” sensory professionals have reached up to 40% in France.

Given such diversity, there are certainly no general rules or methods that may be applied to nonfood products as a single category. It is, however, interesting to review specific features of these types of application from a food sensory scientist’s standpoint. First of all, it is worth noting that while some methodological or theoretical considerations are totally unusual to food sensory scientists, others aspects that will be developed in this chapter are also present when conducting sensory and consumer evaluation of food, but are usually less prominent (e.g., time-dependent evaluation, interaction with context). When looking at these features and the resulting use of sensory evaluation in some

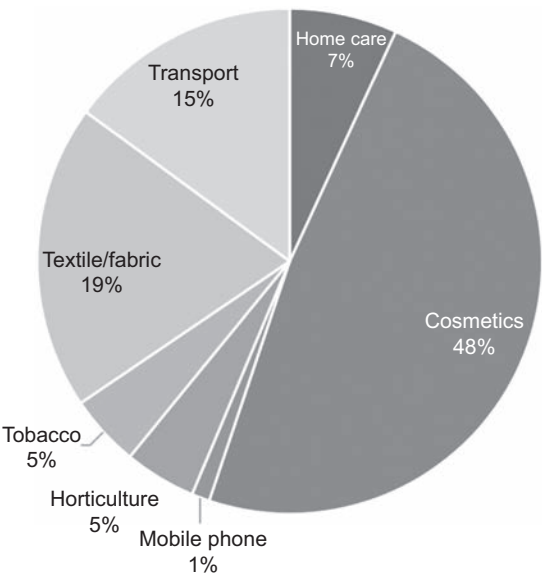


FIGURE 17.2 Distribution of product categories in nonfood studies published in *Food Quality and Preference* and *Journal of Sensory Studies* during the 1986–2016 period.

TABLE 17.1 Penetration of Sensory Scientists into the Nonfood Sector			
Company	Pangborn Symposium 2015 ¹	Society of Sensory Professionals ¹	Société Française d’Analyse Sensorielle
Nonfood	25%	20%	40%
Food and beverage	66%	76%	60%
Nonfood and food and beverage	9%	4%	–

¹Data from Goldman, A. (2015). *Beyond food: has sensory science achieved its potential?* 11th Pangborn Sensory Science Symposium, 23–27 August 2015, Gothenburg, Sweden.

particular cases, we strongly believe that we can draw methodological lessons for the evaluation of food.

1.2 Taking Consumers into Account in Product Design

The main purpose of sensory evaluation techniques, regardless of whether they aim to capture consumer perception or affective responses, is to help

R&D to develop appealing products and then to monitor the sensory quality of these products. Sensory evaluation has also extended to market research with the aim of providing “consumer sensory insights” to product developers and marketers. However, while product development is mainly focused on product formulation in the food (and in the cosmetics) industry, other industries would refer to product design in its broadest meaning. Actually, in the nonfood sectors, design is everywhere. Design is a component of the engineering process. It concerns the creation of a plan for the construction of an object, a system, or a measurable human interaction. It encompasses several disciplines and fields of application, from urban design to software design through product design. Designing often implies simultaneously considering the esthetic, functional, economic, and sociopolitical dimensions of both the designed object and the design process. Although there are several philosophies and approaches to design, the term usually refers to the action-centric model in which designers use creativity and emotion to generate candidates. This model is relevant because, in most cases, designers need to anticipate future consumer needs and desires—often several years before the product is actually launched. Therefore, the task of designing is difficult. In addition to this, designers must cope with engineering and cost management constraints and yet they try to impose their vision. Sometimes, consumers could be forgotten in the process and the final design of a product may eventually reflect the desires of the designer him- or herself and those of the CEO, which may be relevant but certainly not representative of consumers’ diversity.

1.3 Ergonomics

To better take consumers into account in the design process, industries often rely on ergonomics. According to the International Ergonomics Association, ergonomics (also called human factors) is the scientific discipline that deals with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design, to optimize human well-being and overall system performance. In fact, ergonomics draws on many disciplines in its study of humans and their environments, including anthropometry, biomechanics, mechanical engineering, industrial engineering, industrial design, information design, kinesiology, physiology, cognitive psychology, industrial and organizational psychology, and space psychology.

Therefore, ergonomics is a crossing point in the design process. It has theoretical models from the anthropometrics aspects to cognitive ones that are very useful. But these models could also be a drawback because they usually neglect the wide variety of consumers and do not consider their sensations, feelings, and emotions. In its widest acceptance, ergonomics deals with work more than

pleasure and, therefore, it uses tests that may be conducted with only a small number of subjects. For these reasons, product designers have started to use sensory and consumer techniques in addition to ergonomics, precisely because they take into account the diversity of consumers' sensory perception and affective responses.

1.4 Kansei Engineering

When considering the design of nonfood products, it is also worth mentioning Kansei engineering, which is used by engineers to take emotions into account in product design. Kansei engineering originated in Japan in the 1970s and gathers many different methods that are actually better known than sensory evaluation methods in the car industry, where it was first applied. The same would hold in other technological areas. Kansei engineering aims at building models to link the emotional responses of consumers to a product's physical properties. Even if the methodologies may differ, the process is always the same: data collection, construction of rules, and implementation of this set of rules in the Kansei system (Nagamachi, 1995, 2002).

The first task is to collect as many words as possible to describe the domain of interest. These could be gathered by compiling scientific literature, commercials, interviews of experts, etc. The words are then grouped manually or statistically in clusters named with a representative "Kansei word." Concurrently, the experts find the main products representing a domain and identify their key features and physical properties. Then, surveys are conducted with a vast number of consumers (1000+). They are usually asked to score the Kansei words and the physical properties for all the products gathered in the first step (Schütte, 2002). The second step aims at linking the Kansei words and the design attributes with multivariate regression analysis or more sophisticated methods based on genetic algorithms, neural networks, or fuzzy logic.

Kansei engineering is interesting because it addresses the shortcomings of product design and ergonomics. It deals with emotions and perceptions, and the surveys could embrace a vast number of consumers. In addition to this, the models are useful for understanding and predicting the value of future products. But Kansei engineering also has some drawbacks that are tackled by sensory science:

- The technical aspects of the products are described, but quite roughly. There is usually no finesse in the description of these aspects. Therefore, it can be difficult to link the product description and the product conception. With sensory descriptive methods, engineers have more extensive information to work on.
- Surveys are usually conducted using pictures and consumers are not able to touch, smell, or use the products. Obviously, it is often difficult to make up one's mind on a picture.

- Even if the process of semantic research is interesting because it embraces a wide piece of literature, it could be very difficult for consumers to understand what the point is behind a couple of words in opposition.
- And, finally, in contrast to sensory science, Kansei engineering usually does not deal with consumer clustering to take into account their variability, not to mention individual modeling.

In this chapter, we aim to point out the particularities of nonfood products, that is to say, the aspects and issues that are unusual to food sensory and consumer scientists and professionals and their consequences for conducting sensory and consumer research on such products, including pragmatic considerations. When appropriate we give some recommendations about key points to take into account for implementing such tests. Although this could be somewhat artificial, these considerations can be categorized into three main themes: factors linked to the products to be evaluated, those related to usage and, finally, those related to the subjects who will evaluate the products.

2. PRODUCT-RELATED ISSUES

2.1 Sensory Tests, but Not Taste Tests

The predominant role of our senses in the eating and drinking process and in the pleasure that is derived from our sensations during this process is rather obvious. This actually underlies all food sensory and consumer science. However, the most striking characteristic when thinking about running sensory or consumer tests with nonfood products is that the products are not tasted. In fact, people always use their senses and their motor system to interact with products, but focus will often be placed on senses other than taste in its broadest meaning. Smell is often cited as one dimension of interest for many nonfood products, such as new cars (Verriele et al., 2012), home care products (Fenko, Schifferstein, Huang, & Hekkert, 2009), or ambient odors (Kim, Rhyu, & Lee, 2003). However, the evaluation of nonfood products also predominantly implies sensory modalities such as touch for cosmetics (Pensé-Lhéritier, 2015) and textiles (Kergoat et al., 2016), sight for the inspection of product surfaces (Baudet, Pillet, & Maire, 2011), or kinesthetic sensations (Duthoit, Enrègle, Sieffermann, Michon, & Blumenthal, 2017; Duthoit, Sieffermann, Enrègle, & Blumenthal, 2016) and the interactions of these senses.

2.2 Not Just Sensory: Functionality Is Often Key

A major characteristic of all nonfood products is that they have a functionality, which is the main reason people use them. For example, in cosmetics, efficiency or product performance is a major concern (a moisturizing lotion should be perceived as moisturizing; lipstick should last all day long; a deodorant should cover/suppress any smell and limit perspiration). This means that evaluation of

the functionality is part of the assessment process in addition to sensory and pleasurable aspects. This also means that functionality aspects have to be evaluated to be able to understand the hedonic scores of consumers. For example, [Poirson, Petiot, Boivin, and Blumenthal \(2013\)](#) studied consumers' perception of dashboards in terms of esthetics and hedonic aspects, but these authors observed that in real life consumers also consider the trade-off between the esthetics of the dashboard and the inner space of the glove compartment.

As a consequence, any sample or prototype should be functional and realistic for evaluation by consumers to be meaningful. Test participants should thus be given the opportunity to experience the product or at least to see it working (i.e., on a video, a picture, etc.). Experimenters may also need to combine sensory/hedonic approaches with function-oriented approaches such as ergonomics. This is the case for human-machine interfaces in cars, for which [Blumenthal and Dairou \(2007\)](#) developed a list of criteria taking into account sensations but also cognitive ergonomic aspects.

This also implies that evaluation needs to take sufficient time to properly evaluate functionality. For example, a lipstick needs to be tested for several days before a consumer can evaluate not only the sensory aspects (shiny, melting, sticky, etc.) but also the functional ones (lasting, marks on glasses, etc.). Even more acute and obvious, at some point in the development process, car perception must be evaluated while driving on a road. A consumer who is testing a potential future car will have to drive it for at least 45 minutes to make up his or her mind ([Astruc, Blumenthal, Delarue, & Danzart, 2006, 2005](#)).

The importance of functionality reaches the point that sometimes the object under investigation is a function, not an actual product. Research will thus focus on the human-machine interface, whereby emphasis is placed on the way the product behaves or interacts with consumers and not on the sensory properties of the product itself. This is especially true in the automotive industry, in which many functions of a vehicle may be perceived by means of our sensorimotor system, but cannot be seen. For instance, [Dairou, Priez, Sieffermann, and Danzart \(2003\)](#) developed a method combining sensory evaluation and the design of experiments to predict brake feel; [Herbeth, Meillon, and Blumenthal \(2007\)](#) studied a new steering system that may be surprising in terms of sensations (sensory and emotions) but allows the parking of cars with a minimum of arm movements (functionality); [Wellings, Williams, and Pitts \(2008\)](#) investigated the switch feel in luxury sport vehicles.

2.3 Complexity Is Usually the Rule

In addition to the complexity linked to functionality, it should be noted that many nonfood products are multicomponent products. This means that parts of the product can be tested independent of the product or as a part of a whole. Again, cars are powerful examples. Their inner design is composed of seats, a wheel, a dashboard, all sorts of commands, etc. In turn, each element may

be composed of different subparts, and so on. These elements have their own consistency and can be evaluated separately from the car itself. However, measuring consumers' responses to all elements would be practically impossible, because of time and resource constraints. Furthermore, such an approach to consumer perception is not satisfactory because from a user experience perspective, all these elements interact and some perceived dimensions, like "comfort," are holistic in the sense that people integrate all features, mostly unconsciously. This means that in many cases, the full car or a prototype is needed to conduct consumer research.

It is also worth mentioning that, adding to the complexity of the products, the market structure may vary extremely from one product category to another. This would range from the two-competitors-only situation (also very common for food) to a multitude of brands as in the fine fragrance market and its hundreds of references. Consider, for example, that the women's fragrance world bestseller barely reaches 5% of market share. This may affect the choice and the number of products to be tested and their relevance to the consumer target.

2.4 Practical Constraints When Running a Test with Nonfood Products

Other aspects of testing nonfood products are of a more pragmatic nature. Nevertheless, they should be taken into account because they may imply important constraints when planning to run a consumer test.

As for any sensory and consumer research, sampling is to be carefully considered. On the positive side, nonfood products usually have long shelf-lives, which makes them easier to store. In this regard, planning a test and sampling are usually less of a nightmare than with short-shelf-life food. However, constraints could relate to product size, to its cost, or to the difficulty in blinding the samples. In some cases, indeed, product size may be an important constraint. For instance, some products could not fit in a regular sensory testing booth or would require specific equipment in the booth (e.g., for skin care products: a mirror, a washbasin—not just a spittoon, a warm water tap, etc.). In the case of cars, trains, or planes, test participants would literally have to go inside the product. Other products, like fragrances, are not actually large, but they would definitely fill in the space. Once someone has sprayed fragrance or has used a perfumed cleanser in a room, it is difficult to wash out the odor before another sample can be tested or before someone else could evaluate it. One may then want to use airtight booths equipped with air renewal system. In fact, test facilities and trial design would have to be adapted to each case.

Product cost may also be limiting. As a matter of fact, the unit retail price of many nonfood products is frequently higher than that of an average food product. As a result, the supply budget may quickly become important. For

example—quite an extreme example—the cost of a 50-mL antiaging serum vial from a luxury brand may easily reach €400. The sampling budget for testing such products may thus double the total cost of the test, if not more. In the car industry, that cost would be so high that experimenters have to rent competitors' cars or even rely on intercompany loans.

In addition to this, testing products blind can be difficult because most non-food products can be easily recognized even if the brand or logo is masked. For example, a car can be easily recognized by its shape or general design. In other cases, the logo is stamped on the product and impossible to remove or mask without destroying the product (lipsticks, eye shadows, tissues, etc.). Should one wish to run the test blind (which is frequently the case in sensory consumer tests), it would be an important issue to overcome, if possible.

3. USAGE-RELATED ISSUES

3.1 Products That Are Used, Not (Just) Eaten

Obviously, nonfood products are not eaten. Usage is thus not limited to one short consumption episode (i.e., one meal), but may last a few hours to a few days. Product experience is thus even more salient than with food. In addition, as highlighted by [Hekkert and Schifferstein \(2008\)](#), product experience not only results from the way people interact with the product, but also accompanies and guides the interaction, and this affects the interaction. Keeping this in mind is thus a key to understanding drivers of preferences and behavior.

As a result, for some products, evaluation is meaningful only if the product is actually used for its intended purpose and in its natural usage context. This would typically be the case for shaving creams and razors, which must be evaluated when shaving as part of a daily routine. This means that, depending on the product category, participants may be asked to shower, to shave, to drive, to use toilet tissue, to work out, to run, etc. Implementing such tests would of course raise many practical questions, not to mention safety, ethics, and insurance matters.

3.2 Dynamic Measurements

In terms of sensory and hedonic measurements, the fact that products are used for more than a few minutes implies that perception and judgment may vary while consumers experience the products. Tracking these changes may be determinant for product developers to improve their products. Potentially, dynamic measurements may thus be much more relevant than when testing food, whether they are descriptive (time–intensity, progressive profile, temporal dominance of sensations, temporal-check-all-that-apply, etc.), emotional, or hedonic measurements ([Delarue & Blumenthal, 2015](#)). When investigating these aspects, one will have to consider not only the evolution of sensations and hedonic response

with time, but also how some significant moments may affect them. For example, shampoo or hair conditioner may convey very different sensations when opening the bottle, when applying it to the hair, when rinsing, when drying the hair, further on during the rest of the day, and so on. Naturally, in many cases like this, the product may change with time and in interaction with the user. Should one be interested in monitoring these changes in perception and liking, experimental tricks should be imagined to dynamically record consumers' feedback in the context of use. Digital and connected objects offer huge perspectives in this regard and we certainly are only at the very beginning of their use for consumer research.

3.3 Interaction with Context

Another implication of product experience is that context may play an important and complex role in the way consumers perceive and judge the product. Context is known to affect food preferences (see, for example, [Meiselman, 2006](#)). One of the hypotheses that may explain this effect is that context influences attitudes through retrieval of past experiences and of their affective valence ([Delarue & Boutrolle, 2010](#)). This would hold for nonfood products, but a given nonfood product may be used in multiple contexts and have different uses. Memories and associations may thus vary a lot from one context to another. For example, a given vanilla-based home fragrance may evoke totally different mental associations depending on whether it is smelled in the kitchen, the living room, or the bathroom.

What is more, many nonfood products interact with the physical context in which they are used and may thus behave differently from one context to another. This would be the case for many cosmetic products (skin care, hair care, makeup) that will change depending on ambient temperature and humidity. For this reason, cosmetic companies sometimes use climate chambers for sensory evaluation of products that are sensitive to these variations. As mentioned earlier, perception (and therefore liking) of a car, or elements or functions of the car while driving (e.g., seat comfort, steering, etc.), may strongly depend on the type of road, the route, and the traffic conditions. To study consumer appraisal of cars while driving, [Astruc, Sieffermann, Delarue, Danzart, and Blumenthal \(2007\)](#) designed a route intended to be representative of the various types of roads and events (e.g., roundabouts, speed bumps, etc.) that a driver may encounter.

Social context may also play a role, because many products are worn or displayed in front of others and convey an image of the self. For all these reasons, when running a test, it is important to allow consumers to experience the product in different situations and to experience different ways of interacting with the product depending on the context, the intended use, the presence of others, etc.

As a result, for many nonfood products—and this is especially true for cosmetics—home use tests, or more generally “use tests,” are more frequent than central location tests. It may, however, be interesting to try to re-create natural environments to better control testing conditions. Some companies have thus set up individual booths equipped with showers, laundry machines, etc. Also, drawing inspiration from user-centered design, consumer researchers have started using home labs and living labs (Bergvall-Kåreborn, Eriksson, Ståhlbröst, & Svensson, 2009). Despite their strong added value for testing products and understanding user experience, these facilities are expensive to set up and represent only one context at a time. In addition, fully immersive virtual reality (VR) caves have been used very early to help product design (notably cars). Such structures are, however, extremely expensive. It thus comes as no surprise that more affordable, agile, and responsive devices (like VR headsets) raise huge expectations.

4. SUBJECT-RELATED ISSUES

As a consequence of functionality, as well as of the diversity of product categories and usages, consumers may interact with the product in ways that are not commonly considered in food sensory and consumer science. Likewise, consumer responses may not be limited to overall liking, and other response dimensions may be key. This has strong implications for the subjects who should evaluate the products or its effects and the responses that should be measured.

4.1 Interindividual Differences and Segmentation

To properly study consumers’ perceptions of products, one should always keep in mind that people may perceive objects differently, even though we differ less for physical senses (touch, hearing, and sight) than for chemical senses that are more central in food (olfaction, taste). In addition to these interindividual differences in sensory sensitivity that are well known by food sensory and consumer scientists, physiological and anatomical diversity is also to be considered in nonfood applications. People would indeed interact differently with products depending on their size, weight, and muscular strength (e.g., when wearing clothes, using sport equipment, driving a car, etc.). This is one more reason for recruiting large and well-sampled panels of subjects when implementing product tests.

In cosmetics, there will often be a need to recruit a targeted group of subjects with similar hair or skin types. However, recruiting consumers for a test according to their skin type, for instance, may be challenging because of the discrepancy that is often observed between objective measurements of the skin and self-reported skin types (Le Fur, Lopez, Morizot, Guinot, & Tschachler, 1999; Youn, Kim, Hwang, & Park, 2002).

In addition to this, consumers may differ widely in their habits and routines. This goes beyond the usual segmentation into light and heavy users, because the way a given product is used may be totally different from one person to another, or from one country to another. Daily beauty routines are a good example of such differences. They are completely individualized and yet strongly embedded in each culture. For instance, Japanese and Korean beauty routines are both complex (up to 10 steps) and widely differ from each other. In the same line of thinking, it should be noted that consumers develop skills at using products and may be recruited according to these skills. In this regard, the most striking example that we have seen is the recruitment of quite highly ranked tennis players to evaluate tennis gear. It was indeed necessary to recruit subjects that were skilled enough to focus on their sensations while playing. One may face similar needs when implementing a test of products whose use implies high cognitive load.

Eventually, it must be noted that—in contrast to food—not only the person who uses the product may perceive it. Nonfood products (or the result of their use) may indeed be seen, smelled, or touched by others. As a result, other people's judgment matters too. In some studies, consumers are thus sometimes asked to evaluate the result of the use of a product on other people or in their pictures. This would typically be relevant for skin care, makeup, or even fine fragrance for the scent trail. In such cases, the person who uses the product or to whom the product is applied may be different from the person who judges the product. Some products would also imply a third type of person, who will apply the product on the model (e.g., professional hairdressers for hair care products, beauticians for makeup). These experts would warrant that the product is applied according to their standards, but they may also be asked for their opinion on the product.

4.2 Consumer Response: Beyond Liking

Because of their functional and social values, many nonfood products imply a strong emotional response (at least stronger than with most “regular” food products). Consumer appraisal is thus usually not limited to liking, but may also include other dimensions relating to abstract conceptualizations. These conceptualizations may have emotional connotations or functional connotations (Thomson, 2010). Determinants of these concepts may be of a different nature. For example, Labbe, Gilbert, Antille, and Martin (2009) observed that complex perceptions such as refreshing or naturalness are based on multiple sensory determinants, as well as physiological, psychological, and social factors. Furthermore, Westerink and Kozlov (2004) explained that freshness depends on different sensory, physiological, and cognitive factors. In addition to this, it is reasonable to hypothesize that they often bear a hedonic valence. However, neither a pure sensory description nor a hedonic testing can take full account of these percepts. Perceived or projected dimensions of the product are in fact

subjective and would also depend on self-image and social representations and they may affect well-being in its broadest sense.

In addition to measuring liking or purchase intent, measuring these conceptualizations or subjective dimensions is thus critical for companies that aim at better understanding their consumers' preferences and behavior. Modern sensory descriptive techniques can be useful in this regard. Actually, an increasing number of sensory descriptive studies are being carried out with consumers to capture their perceptions of products, in addition to measuring the sensory characteristics of products (Varela & Ares, 2012). They address the need to go beyond sensory description as provided with trained panelists. One could draw inspiration from food studies, where the most frequently reported subjective dimensions are "natural" (Mireaux, Cox, Cotton, & Evans, 2007; Veinand, Godefroy, Adam, & Delarue, 2011), "artificial" (Ares, Varela, Rado, & Gimenez, 2011; Vidal, Ares, & Gimenez, 2013), and "healthful" (Raz et al., 2008; Roininen, Arvola, & Lähteenmäki, 2006; Russell & Cox, 2003). Similar published works with nonfood products have investigated subjective dimensions such as the freshness of dishwashing liquids (Fenko et al., 2009), the comfort of clothing (Kamalha, Zeng, Mwasiagi, & Kyatuheire, 2013), or gentle and powerful for bottles of mouthwash (Parise & Spence, 2012). Investigating these dimensions may be very informative and helpful to relate preferences to their sensory and technical determinants.

5. CONCLUSION

In this chapter, we have outlined the issues and specific features of consumer research on nonfood products. Of course, the methods and rules developed in food sensory and consumer science do apply to nonfood products. This is why nonfood companies seek expertise from sensory science. However, we hope to have shown that consumer researchers and professionals in nonfood sectors also need to build on other disciplines, notably design and product experience (Schifferstein, 2015). In turn, we strongly believe that we can draw methodological lessons from nonfood applications for the evaluation of food. For sensory and consumer scientists, the issues that are reported here are also a window to other techniques and approaches that may contribute to enriching our theoretical and methodological spectrum.

In line with Hassenzahl's research on ergonomics quality, we would like to emphasize the importance of both the consumer's and the developer's evaluation to product development (Hassenzahl, 2001; 2003). Fig. 17.3 highlights the fact that three dimensions of product quality are to be considered (functional, sensory, and socioenvironmental). We also believe that context is absolutely key to understanding how these qualities are perceived and how they influence consumers' judgment, behavior, and emotions. We hope that these considerations will give rise to future research in both nonfood and food applications.

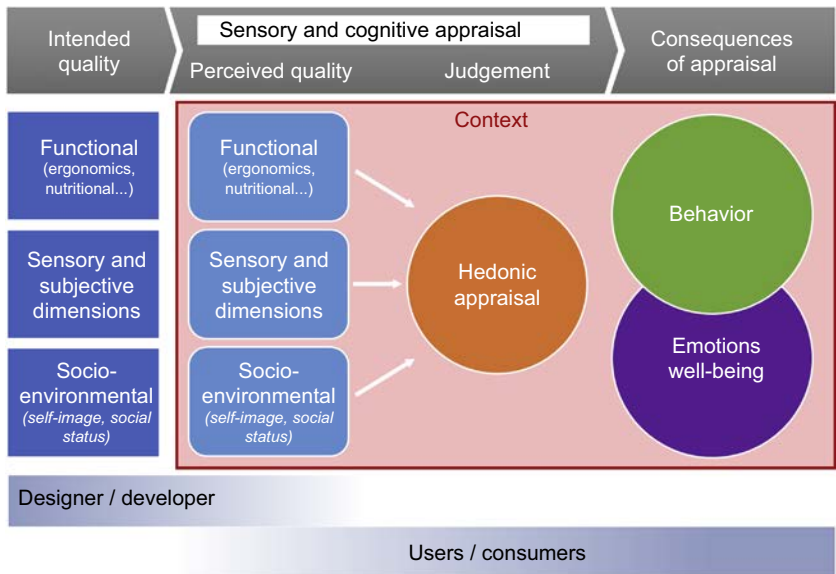


FIGURE 17.3 Research model for appraisal of product quality. (Adapted from Hassenzahl, M. (2001). *The effect of perceived hedonic quality on product appealingness*. International Journal of Human Computer Interaction, 13, 481–499.)

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Chapter 18

Consumer-Driven Product Design

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1. WHAT IS PRODUCT DESIGN?

Product design is increasingly recognized as an important strategic tool, responsible for the success of leading brands such as Apple and BMW (Brunner, Emery, & Hall, 2008), as well as a tactical tool by which niche brands can differentiate themselves from competitors (Jana, 2008). Studies have demonstrated that optimizing product design can ensure the successful launch of new products (Nair, Thakur, & Wen, 1995; Srinivasan, Lilien, & Rangaswamy, 2006) and ongoing market success of existing products (Meyer, Tertzakian, & Utterback, 1997; Sundgren, 1999).

There are many definitions of product design. When designers themselves try to define design, they usually start by distinguishing “form” from “function,” where “form” refers to physical form (including product shape, color, and material), which is related to esthetic components of a product (Bloch, 1995; 2011; Chitturi, Raghunathan, & Mahajan, 2007). Bloch (2011) suggests that product form provides utilitarian, hedonic, and semiotic benefits to the user. The physical form of a product attracts consumers to a product, communicates to them, and adds value to the product by increasing the quality of the usage experiences associated with it (Bloch, 1995).

Function is characterized by the structural and technological features that collectively provide the utility of a product (i.e., utilitarian benefits). For instance, Kohli and Krishnamurti (1987) treat product design as the selection of the optimal set of functional attributes. Some design studies try to integrate form and function. For instance, Krishna and Morrin (2007) have demonstrated that the product form can influence perceptions of functional performance. Verganti (2008) suggests that product functionality aims at satisfying the utilitarian needs of customers, while the emotional and symbolic product meaning satisfies their affective and sociocultural needs.

In addition to the object of design (i.e., the product, which could be a tangible good and/or a service), product design also refers to a process. This process-oriented perspective is described as one in which product design is incorporated into the product development process (e.g., Crawford & Di Benedetto, 2008; Perks, Cooper, & Jones, 2005; Ulrich & Eppinger, 2007; Veryzer & Borja de Mozota, 2005).

Based on the analysis of a broad set of articles addressing product design, Luchs and Swan (2011) proposed the following definitions of design:

- *Product design*: the set of properties of an artifact, consisting of the discrete properties of the form (i.e., the esthetics of the tangible good and/or service) and the function (i.e., its capabilities) together with the holistic properties of the integrated form and function
- *Product design process*: the set of strategic and tactical activities, from idea generation to commercialization, used to create a product design

Both of these definitions are useful in understanding the emerging area of consumer-driven product design, which can be seen as the joint effort of consumer researchers, marketers, designers, and product developers. Consumer researchers and marketers focus on the effects of product design on the wide range of consumer responses, including esthetic appreciation, product experience, symbolic meaning, and customer satisfaction. They aim to answer the following research question:

- How does product design influence consumers?

Designers and product developers are interested in the practical application of consumer responses in their work. Various methods and practical tools have

been developed to involve consumers in the process of product design to maximize the match between product design and consumer needs. Designers and product developers aim to answer the following questions:

- How should data on consumer needs and preferences be obtained?
- How should consumers be involved in the design process?

Although the studies within the areas of consumer behavior and product design are usually performed independently, they are closely connected to each other. Designers try to adjust product design to consumers' needs and enhance product experience by involving consumers in the design process. Consumer researchers and marketers recognize the importance of good design in consumer satisfaction and product success and investigate the effects of product design on consumer responses, including product experience, esthetic pleasure, and consumer satisfaction. Their findings can be used by designers to guide the process of design and to test its preliminary results (ideas, concepts, prototypes).

2. CONSUMER INVOLVEMENT IN THE DESIGN PROCESS

Designers try to involve consumers in the design process at different stages of their work. The degree to which consumers can be involved in the design process has been divided into three categories: “design for consumers,” “design with consumers,” and “design by consumers” (Kaulio, 1998).

Design for consumers is an approach to designing products on behalf of the consumers. Data on users and general theories and models of consumer behavior are used as a knowledge base for design. This approach often also includes specific studies of consumers, such as interviews or focus groups. The approach focuses on an initial diagnosis and a transformation of these initial requirements into performance measures. Van Kleef, van Trijp, and Luning (2005) describe 10 methods of consumer research that designers employ at the early stages of product development to obtain consumer data. These methods include category appraisal, conjoint analysis, empathic design, focus groups, free elicitation, information acceleration, the Kelly repertory grid, laddering, lead user technique, and the Zaltman metaphor elicitation technique. In addition, such methods as data mining, user-generated content, and Kansei engineering have been becoming more and more popular.

Design with consumers involves consumers in the design process by presenting consumers with different design solutions or concepts and measuring consumer responses. It can be seen as an iterative approach to product design, as different models or prototypes are shown to consumers at different stages of the design process and are then revised. The consumers react to one or several product concept(s) presented, and the information is returned as feedback to the designers. The design with consumers strategy can be described as a way of maintaining a formal dialogue with consumers. Examples of methods from this group include user-oriented product development (Rosenblad-Wallin, 1988),

concept testing (Acito & Hurstad, 1981; Dahan & Mendelson, 2001; Moore, 1982; Page & Rosenbaum, 1992), and beta testing (Dolan & Matthews, 1993; Nielsen, 1993).

Design by consumers represents an approach whereby consumers are actively involved and participate in the design of their own product. Consumers take part in product design not only by formulating their problems, needs, and wishes, but also by being actively included in the process of developing and selecting different design solutions. The designer becomes a facilitator who helps the consumers to find solutions to their problems by actively engaging them in the design process. One of the methods of design by consumers is mass customization.

Mass customization requires the consumers and designer to develop the product together so as to provide consumers with exactly the product they want (Kamali & Loker, 2002). Davis (1987) and Pine (1993) conceptualized mass customization as a business strategy that involved customers in the development process of a product or service to address individual needs. The goal of mass customization is to provide consumers with a differentiated, low-cost product with input from the consumer. For instance, Nike, Inc., developed their mass customization web program NIKEiD in 1999. The program enabled online customers to choose the color of their shoes and to add a personal name to it. In 2001 another footwear company, Adidas, launched their “miadidas” initiative, which was focused more on customized fit rather than customized design. The company used foot scanners for precise foot measurements in retail outlets. Consumers received their customized shoes within 3 weeks. Mass customization has also been adopted by the food industry. For instance, in 2011 Coca-Cola launched a mass personalization campaign “Share the Coke.” The company selected the 150 most popular names within each country and printed them on Coke bottle labels.

A key assumption of mass customization is that customized products create higher benefits for consumers than standard products because they deliver a closer preference fit (Franke, Keinz, & Steger, 2009). The prerequisite for this effect is the ability to obtain precise information on what consumers actually want. But are consumers able to specify their preferences that precisely? Several theoretical arguments raise doubts about this, implicitly challenging the value of customization. Franke et al. (2009) found that products customized on the basis of expressed preferences bring about significantly higher benefits for consumers in terms of willingness to pay, purchase intention, and attitude toward the product than standard products. The benefit gain is higher if consumers have (1) better insight into their own preferences, (2) a better ability to express their preferences, and (3) greater product involvement. This suggests that customization has the potential to be a powerful marketing strategy if these conditions are met. In the opposite case, firms willing to serve heterogeneous customer preferences need to adapt their customization systems in such a way that they explicitly address the customers’ inability to provide valid preference information.

The example of mass customization illustrates the most important challenge of consumer-driven design: to design the products that best satisfy consumers' needs and preferences, designers need to understand these needs and preferences. In many cases, it is impossible to do so by asking consumers directly about their needs and preferences. The more effective approach is to gain insights into consumer needs and preferences by systematically studying consumer responses to product design.

3. CONSUMER RESPONSES TO PRODUCT DESIGN

Empirical studies of consumer responses to product design are centered on the relationship between the objective product features and the subjective consumer responses that are associated with them (Bloch, 1995; Coates, 2003; Crilly, Moultrie, & Clarkson, 2004; Crozier, 1994; Monö, 1997). Research typically involves presenting consumers with a range of product forms that vary in some measurable way and then measuring how consumers respond to those forms.

Several theoretical frameworks have been developed to categorize consumer responses to product design. These frameworks reflect different perspectives that the researcher can adopt when attempting to understand consumer responses.

The designer perspective makes a clear distinction between product form and product function and puts an emphasis on consumer responses to product form. Crilly et al. (2004) distinguish “esthetic,” “semantic,” and “symbolic” responses. Esthetic response is defined as the impression that results from the perception of attractiveness (or unattractiveness) in products; semantic response as the interpretation of a product's function, mode of use, and other qualities; and symbolic response as the associations that are made between the characteristics of a product and the identity of its owner or user. Similar categories of “esthetic,” “instrumental,” and “symbolic” responses can be found in Rafaeli and Vilnai-Yavetz's (2004) exploration of the relationship between physical artifacts and emotions, and the studies of Mahlke et al. (2007) on human-computer interaction.

The framework of product experience (Desmet & Hekkert, 2007) also mentions esthetic pleasure as one of the components or levels of product experience. However, this framework puts more emphasis on the psychological reactions of consumers elicited by products rather than on designers' intentions to communicate certain product benefits. This framework represents *the consumer perspective* on product design. This framework distinguishes between three components of product experience: esthetic pleasure, attribution of meaning, and emotional response. Esthetic, or sensory, experience (Fenko & Schifferstein, 2012) relates to sensory appreciation of a product's properties. A product can be beautiful to look at, make a pleasant sound, feel good to touch, and smell nice. Attribution of meaning relates to the categories of semantic or cognitive response. Through cognitive processes, like interpretation, memory retrieval, and associations,

consumers are able to recognize metaphors, assign personality or other expressive characteristics, and assess the personal or symbolic significance of products. Emotional experience is related to the affective responses to the product (e.g., happiness, boredom, or annoyance).

The semiotic perspective on product design focuses on viewing products as signs capable of representation (Vihma, 1995). Semiotics relates to the symbolic meaning of a product design (Van Rompay, Pruyn, & Tieke, 2009). Designers try to communicate attributes such as elegance, sophistication, or social significance through the medium of the product. Products are considered signs that are interpreted by users, while consumer responses to products can be seen as a stage in a process of communication (Krippendorff & Butter, 1984). Product design is interpreted by users and communicates important information (Bloch, 2011). Monö (1997) suggested that design has several communicative functions. It helps users identify a product's brand origins, category, purpose, and usage. Design also signals intangible traits such as strength and newness (Radford & Bloch, 2011). Finally, design can communicate information about the product user and provide a means for self-expression (Belk, 1988). For instance, a car can communicate the social status of its owner; a watch can serve as a sign of interpersonal relationships if it was a gift from a significant other.

The managerial perspective on product design focuses on consumer satisfaction, which is usually defined as “evaluation of product quality or value based on the comparison of the consumers’ experience with a product or service, their expectations and confirmation or disconfirmation of these expectations, i.e., the degree of discrepancy between actual and expected quality...” (Anderson, 1994, p. 20).

In the following, we give an overview of studies performed within the four conceptual frameworks: (1) product esthetics, (2) product experience, (3) semiotics, and (4) consumer satisfaction (see Fig. 18.1).

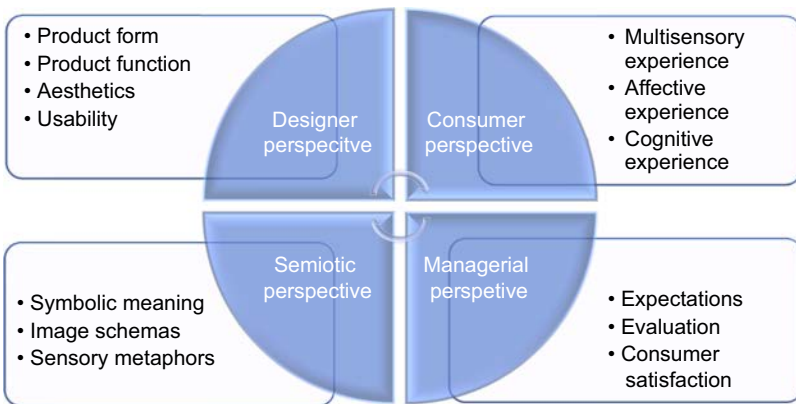


FIGURE 18.1 Conceptual framework of consumer-driven product design.

3.1 Designer Perspective: Product Esthetics

People may look at objects and find them visually attractive, elegant, or beautiful (Crilly et al., 2004). This positive esthetic impression has interested design researchers for decades (Berlyne, 1974) and art theorists and philosophers for centuries before them (Crawford, 1974).

The term esthetics is commonly used to refer to two different concepts:

- In the context of product, esthetics relates to what the product presents to the senses, especially vision (Lewalski, 1988).
- In the context of esthetic experience, it relates to one particular aspect of cognitive response: the perception of how pleasing an object is (Csikszentmihalyi & Robinson, 1990).

Berlyne (1974) suggested that the esthetic pleasure associated with the perception of a stimulus will peak when there is an optimum level of psychological arousal; too little arousal will result in indifference, while too much will result in displeasure. Berlyne (1970) considered whether novelty has a natural antagonistic effect on familiarity and whether complexity mediates favorable esthetic judgments of novel or familiar objects. According to Peracchio and Meyers-Levy (1994), an object that is moderately different from a category will be better liked than either a similar or an extremely different object. Similar findings were reported by Hekkert, Snelders, and van Wieringen (2003) in the study of the complex relationships of novelty, originality, and familiarity in the esthetic preferences for consumer products.

In addition to the combination of lines, colors, textures, and details that comprise the product's visual form, the consumer's familiarity with other products, entities, and concepts also influence esthetic impression. With respect to the last, the *processing fluency framework* (Lee & Labroo, 2004; Reber, Schwarz, & Winkielman, 2004) can account for such effects. In general terms, this framework suggests that stimuli that can be processed more easily are evaluated in more positive terms. For instance, *gestalt* features such as contrast and symmetry make it easier to visually process a stimulus, which explains why we find an overall preference for symmetry and contrast. Interestingly, the mere-exposure effect (stating that objects are evaluated more positively when seeing them more often; Zajonc, 1968) can also be accounted for in terms of processing fluency. That is, less information processing is needed for familiar objects (i.e., objects we have seen before), as we are already acquainted with their appearance. Apart from gestalt features and familiarity, a match between different product or advertising elements (e.g., slogan and product appearance) has also been shown to facilitate processing and boost evaluations (Van Rompay et al., 2009).

Product esthetics is regarded as the critical design element that works in concert with utilitarian benefits to create important first impressions and long-term consumer satisfaction (Bloch, 2011). In recent years, considerable effort has

been made to investigate consumers' perceptions of product esthetics (Bloch, Brunel, & Arnold, 2003; Crilly, Moultrie, & Clarkson, 2009; Radford & Bloch, 2011; Van Tilburg, Lieven, Herrmann, & Townsend, 2015). Empirical studies have investigated cognitive responses to product esthetics, such as brand categorization (Kreuzbauer & Malter, 2005) and product quality judgments (Page & Herr, 2002). The results indicate that consumers make their initial judgment about the product through their esthetic experience, and this judgment may have an impact on the overall evaluation of product performance. In other words: "Attractive things (seem to) work better" (Norman, 2002). In addition, purchase decisions are typically made based on consumers' judgment of visual novelty and distinctiveness of products.

Therefore, designers use their skill, training, and experience to create products that induce a positive esthetic impression. However, designers and consumers often interpret products differently and express different esthetic preferences (Hsu, Chuang, & Chang, 2000). Thus, measuring consumer response to products may offer the opportunity to modify designs and more closely align them with consumers' esthetic preferences.

An example of careful measurement of consumer responses to esthetic product characteristics can be found in the study of Reimann, Zaichkowsky, Neuhaus, Bender, and Weber (2010) on the effects of package design on consumers' behavioral, neural, and psychological responses. Participants were presented with product packages that were manipulated according to three factors: packaging design (esthetic vs. standardized), brand (well known vs. unknown), and price (30% above average vs. 30% below average) (see Fig. 18.2). Participants choose esthetic package designs with an unknown brand and at a low price significantly more often than a well-known brand at a low price but in a standardized package (73% vs. 54%). Even when the price was high, participants still chose the esthetic product packaging with an unknown brand over the standardized package with the well-known brand (51% vs. 42%). Thus, consumers may pay a premium price when receiving an esthetically pleasing product.



FIGURE 18.2 Examples of product packages used in the Reimann et al. (2010) experiment.

It is widely assumed that esthetic designs trigger positive consumer responses, including an immediate desire to own the product (Norman, 2004), a higher willingness to pay for it (Bloch et al., 2003), and increased inclination to show off and care for that product (Bloch, 1995).

Researchers interested in the esthetics of food have started to assess people's overall preferences when it comes to the visual composition of food on the plate, and the impact that this may have on the consumption experience. In experimental esthetics it is often assumed that people prefer balanced over unbalanced visual compositions. Zellner, Lankford, Ambrose, and Locher (2010) investigated whether balance and complexity (increased by the addition of color) in the presentation of food on a plate affect the attractiveness of the presentation similar to how these factors affect the attractiveness of works of art. While color increased the attractiveness of the balanced presentation it did not increase the attractiveness of the unbalanced one. However, there was no effect of color or balance on liking for the flavor of the food. The authors conclude that manipulating color and balance in food presentation can affect its attractiveness, but it does not alter how much one likes the flavor of the food. Velasco, Michel, Woods, and Spence (2016) have shown that principles borrowed from the visual arts can, to a certain extent, be applied to plating. In a series of field experiments the authors demonstrated a clear preference for balanced over unbalanced presentations of exactly the same ingredients over all compositions.

However, for some product categories (such as utilitarian products) esthetic features may induce negative consumer evaluations of functional product properties. For instance, Hoegg, Alba, and Dahl (2010) investigated the interaction of esthetic design and product evaluation, testing the conventional wisdom among practitioners that “what is beautiful is good.” In this study, consumers were asked to evaluate functional properties of cooking pans and grills (predominantly utilitarian products) under three conditions: without a picture, with the picture of an unattractive design, and with the picture of an attractive design (see Fig. 18.3). The results showed that consumers evaluated product functionality lower when they saw an attractive design compared to an unattractive design and the control condition (without a picture). This bias in the direction of the unattractive product demonstrates the existence of a negative esthetic effect, which is probably based on heuristic processing (“This product is too beautiful to work well”).

Crozier (1994) argues that the differences between peoples' judgments make it difficult to believe in universal esthetic principles. He suggests that the visual appeal of objects is influenced by sociocultural, socioeconomic, historical, and technological factors. As such, the ideals and standards to which one culture aspires may not be appreciated by other cultures. This issue of cultural taste indicates that the objective properties of a design are insufficient, in themselves, to explain judgments of attractiveness. The consumers' subjective experiences are also important and contribute to esthetic impressions. For example, prior experience will influence the perception of product

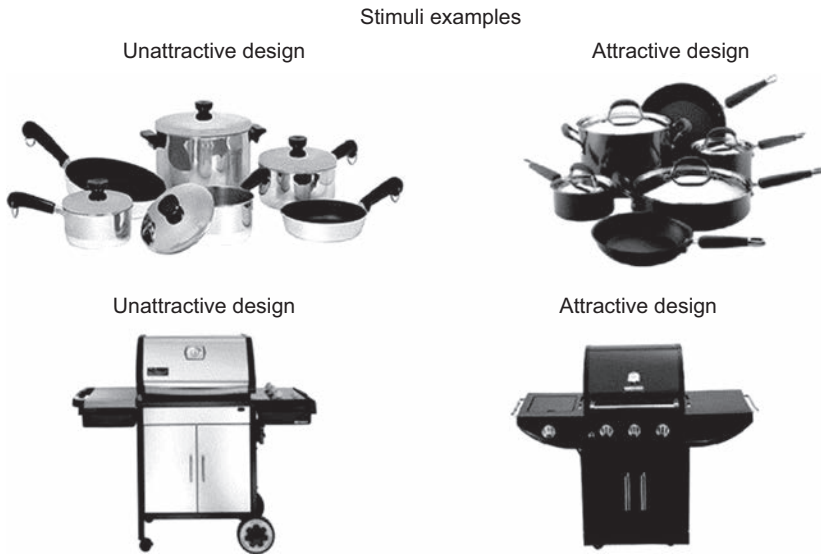


FIGURE 18.3 Products (cooking pans and grills) used in the experiment of [Hoegg et al. \(2010\)](#).

typicality and novelty, two factors that have been shown to strongly affect esthetic preference ([Hekkert et al., 2003](#)).

3.2 Consumer Perspective: Product Experience

While designers tend to conceptualize the effects of product design on consumers in terms of “form,” “function,” and “esthetics,” consumers themselves rarely express their responses to products in these terms. When asked about their reactions to products, they share their experiences, which include sensory perception (“The product is bright red and feels smooth when I touch it”), their emotions (“I love it” or “It is boring”), and what the product means to them (“It is feminine, modern, sophisticated” or “It reminds me of my father”).

To better capture consumer responses to products, [Hekkert and Schifferstein \(2008\)](#) introduced the framework of product experience. They define product experience as “the awareness of the psychological effects elicited by the interaction with a product, including the degree to which all our senses are stimulated, the meanings and values we attach to the product, and the feelings and emotions that are elicited” ([Hekkert & Schifferstein, 2008](#), p. 2).

Both in everyday life and in experimental research, it is difficult to differentiate the three main components of product experience outlined in this definition. Sensory perception, especially in the case of visual and auditory modalities, is closely connected to cognitive processes ([Goodale & Humphrey, 1998](#); [Neisser, 1994](#); [Paivio, 2006](#)). Also, some sensory modalities (especially touch, smell, and taste) are strongly associated with emotions ([Hinton & Henley, 1993](#); [Sweetser, 1990](#)). Furthermore, affective and cognitive processes, which are usually described

as distinct, often blend together in everyday life: our attention is drawn to emotional stimuli; emotional events are retained in memory; and judgment sometimes involves weighing emotional consequences (Hollins, 2010).

3.2.1 *Multisensory Product Experience*

Sensory properties of products represent the most “objective” component of product experience. Indeed, whether we like it or not, we smell the food while cooking it, hear the sound of a vacuum cleaner while cleaning a room, and feel the bumps of the road while driving. Sensory experiences tie us to the material world and to the objects that make up our environment. Nevertheless, sensory experiences are not immune to the “subjectivity” of our affective reactions, symbolic meanings, beliefs, and values that we attribute to products.

Almost all product experiences have associations with more than one sensory modality. The color of a dress can be “loud,” the voice of a singer can be “sweet,” and so on. Most of our product experiences are multisensory (Fenko, Otten, & Schifferstein, 2010; Schifferstein & Spence, 2008). Our perception of a product is based on the integration of information gathered from different perceptual modalities: the products we perceive have shapes, colors, movements, but also sounds, odors, and textures sensed through active touch. The senses interact and influence one another in extraordinary and sometimes unexpected ways. As a result, what we experience may be different from what our sensory systems have initially encoded.

People’s perception of the attributes of a product in a given sensory modality is frequently affected by the sensations that are simultaneously being perceived by another modality. For example, in a classic study, Laird (1932) found that women evaluated the quality of silk stockings more positively when they were scented with a narcissus scent compared to their natural (slightly rancid) scent. Demattè, Sanabria, Sugarman, and Spence (2006) followed up on Laird’s (1932) study. The participants in their experiment were asked to rate the perceived softness of fabric samples impregnated with different fragrances. Fabrics were rated as significantly softer when presented with a lemon or lavender odor than when presented with an animal-like odor. In another study, Zampini, Guest, and Spence (2003) asked their participants to evaluate the roughness of an electric toothbrush. The toothbrush was judged to be rougher when the overall sound level was increased and when the high-frequency sounds were amplified. The same type of auditory manipulation has also been found to affect the perceived forcefulness of aerosol spray sounds (Spence & Zampini, 2007), the level of perceived carbonation in sparkling water drinks (Zampini & Spence, 2005), and the perceived crispness of potato chips (Zampini & Spence, 2004). Research on odor–texture interactions has shown that increasing the hardness of a gel leads to a decrease in perceived intensity of its flavor, while flavor release from the gel is hardly affected (Bult, de Wijk, & Hummel, 2007; Weel et al., 2002). Furthermore, essentially tasteless odorants may enhance the perceived intensity of a specific taste (Frank, van der Klaauw, & Schifferstein, 1993).

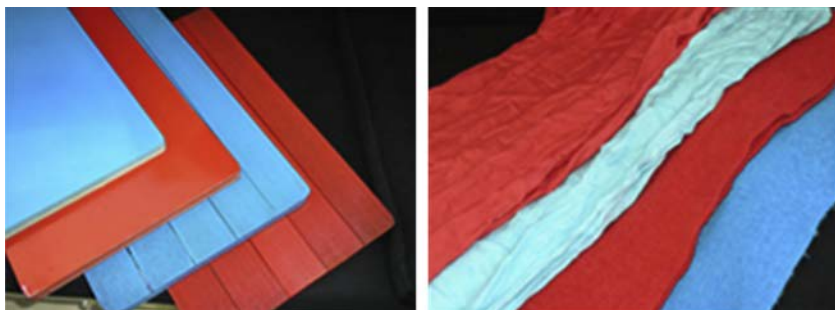


FIGURE 18.4 Products (breakfast trays and scarves) used in the experiment on warmth (Fenko, Schifferstein, et al., 2010).

Correspondences that people perceive across different sensory modalities can be formed through prior experience (Spence, 2012). If certain pairs of sensory stimuli are more likely to occur together, people might perceive some resemblances among colors, sounds, tastes, smells, and other sensory stimuli. Cross-modal correspondences can be also linguistically mediated. For instance, pretty much every language uses the same words, “low” and “high,” to describe stimuli that vary in pitch. In addition, sensory experiences may be associated with symbolic meaning. For instance, the experience of *warmth* has both a literal aspect, associated with the thermal characteristics of products, and a figurative aspect associated with the metaphorical meaning of warmth (i.e., intimacy).

To study the importance of visual and tactile product properties on the multisensory experience of *warmth*, Fenko, Schifferstein, and Hekkert (2010) designed products (scarves and breakfast tables, see Fig. 18.4) using warm and cold stimuli (colors and materials) in four different combinations and asked respondents to evaluate the warmth and pleasantness of each product. The results demonstrated that both color and material contribute equally to the judgments of warmth in both products. Spontaneous comments suggest that participants of the study assessed dark scarves as warmer, because they considered dark colors more suitable for a winter outfit than light colors. Surprisingly, wool had a lower warmth rating than fleece; in this case respondents commented that they did not like wool because it irritated their skin. This study demonstrates that sensory product experiences can be influenced by perceived product appropriateness. For instance, red and yellow are usually perceived as warm colors, with blue and green as cold colors (Wright, 1962). However, green scarves were rated higher on warmth than yellow scarves (Fenko, Schifferstein, et al., 2010). Participants commented that yellow is “too bright and more suitable for a spring scarf,” while green is “darker and more suitable for a warm winter scarf.”

Freshness is another example of a multisensory product experience that can trigger different affective responses. In their experimental study, Fenko, Schifferstein, Huang, and Hekkert (2009) created products (soft drinks,



FIGURE 18.5 Products (soft drinks, dishwashing liquids, and scented candles) used in the experiment on freshness.

dishwashing liquids, and scented candles, see [Fig. 18.5](#)) using fresh and non-fresh stimuli (colors and smells) in four different combinations and asked respondents to evaluate the freshness and pleasantness of each product. The results demonstrated that smell dominated the judgments of freshness for soft drinks and dishwashing liquids. However, for scented candles smell and color were equally important in determining freshness. These results imply that sensory dominance may differ between product categories. The results also indicate that negative emotions were mainly triggered by inconsistent combinations of olfactory and visual stimuli rather than by the unpleasant smell as such.

Product *noisiness* is a multisensory product experience that integrates auditory and visual components. [Fenko, Schifferstein, and Hekkert \(2011\)](#) manipulated auditory and visual properties of alarm clocks and whistling kettles to find to what extent the overall product noisiness depended on the sounds these products made or could be influenced by the visual appearance of the products (see [Fig. 18.6](#)). The results demonstrated that the overall experience of noisiness or annoyance was influenced mainly by the sound. The noisiness of the sound had a negative influence on the overall pleasantness of the products. However, the results showed differences in sound experience between products. While mean noisiness ratings for whistling kettles varied depending on sound frequency and complexity, all alarm clock sounds were assessed as quite noisy. This result may be explained by a difference in



FIGURE 18.6 Products (whistling kettles and alarm clocks) used in the experiment on noisiness.

ffective associations attached to these two products. The sound of a whistling kettle may be associated with the pleasant experience of making tea, while the sound of an alarm clock is typically associated with the unpleasant experience of waking up early in the morning. These memories may influence the experience of noisiness of product sounds, suggesting that perception of sensory product properties depends on previous experience and affective associations.

The importance of a particular sensory modality in product experience depends on the type of product, the stage of user–product interaction, and the language that is used to conceptualize and communicate the experience (Fenko & Schifferstein, 2012). During the various stages of user–product interactions, different sensory modalities may be important. Schifferstein, Fenko, Desmet, Labbe, and Martin (2013) investigated how a dehydrated food product was experienced at different stages of product usage: choosing a product on a supermarket shelf, opening the package, cooking, and eating the food. At the buying stage, vision was the most important modality, followed by taste. This result is in line with previous research (Fenko, Schifferstein, & Hekkert, 2009), which demonstrated the dominance of vision at the buying stage for a variety of industrial products. Smell was dominant at the cooking stage, and taste was the most important sensation while eating the food. The most surprising finding in regard to sensory importance dynamics was the

relatively high rating of taste at the buying stage, although participants had no actual gustatory sensations. This result shows that the answers may reflect not only actual sensory experiences, but also people's expectations or ideas of what they might or should experience.

3.2.2 *Affective Product Experience*

In psychology, the term affect, or affective state, is generally used to refer to all types of subjective experiences that are valenced, that is, experiences that involve a perceived goodness or badness, pleasantness or unpleasantness. In experimental research, valence is traditionally used as a bipolar dimension to describe and differentiate between affective states (e.g., [Bradley & Lang, 1994](#); [Plutchik, 1980](#); [Wundt, 1904](#)). [Russell \(1980, 2003\)](#) introduced the concept of “core affect” by combining the affect dimension with physiological arousal into a two-dimensional model. According to Russell, the experience of core affect is a blend of those two dimensions: valence (unpleasant/pleasant) and arousal (calm/excited).

In product design, it is important to promote positive, pleasurable product experiences and to prevent frustration, pain, and stress being associated with product usage ([Hancock, Pepe, & Murphy, 2005](#)). Traditionally, designers concentrated on preventing negative emotions during product usage, but recently they have been paying more and more attention to creating pleasurable products ([Jordan, 2000](#)), exciting product experiences ([Norman, 2004](#); [Desmet, 2002](#)), and enjoyable product–user interactions ([Han & Hong, 2003](#); [Helander & Tham, 2003](#); [Khalid, 2004](#); [Krippendorff, 2004](#)).

In this context, the idea of one-to-one correspondences between the sensory attributes of products and the users' affective reactions seems very tempting. Various researchers (e.g., [Hancock et al., 2005](#); [Norman, 2004](#)) have created lists of such attributes that result in the user's experience of products and services as pleasurable. Some examples of attributes that induce positive affect are smiling faces, warmth, comfort, sweet tastes, pleasant smells, bright and highly saturated colors ([Martindale & Moore, 1988](#)), harmonious music and sounds, rhythmic beats, and symmetrical, round, smooth shapes. Attributes that induce negative affect include darkness; harsh, abrupt sounds; startling noises; bitter tastes; sharp objects; rotting smells; decaying foods; sudden, bright lights; and extreme temperatures ([Murphy, Stanney, & Hancock, 2003](#)).

The impact of sensory stimuli on affective experience was reported in empirical studies on consumer behavior. The classical research in this domain is the investigation by Zajonc and colleagues into mere exposure, whereby simply being exposed repeatedly to a stimulus leads to more positive affective reactions ([Kunst-Wilson & Zajonc, 1980](#); [Zajonc, 1968](#)) due to familiarity ([Whittlesea, 1993](#)). Consumer studies also find a positive relationship between the typicality of an object (or similarity to other members of a category) and the affective evaluation of this object. In general, more typical objects are better liked

(Carpenter & Nakamoto, 1996; Siminon & Ruth, 1998; Veryzer & Hutchinson, 1998; Zhang & Sood, 2002). Other sensory variables that were reported to influence affective judgments include symmetry (Frith & Nias, 1974) and the principles of good gestalt (Arnheim, 1954). These findings are in line with the previously discussed processing fluency framework (Reber et al., 2004).

However, affective responses to a product often differ at different stages of user-product interactions. One of the examples of such differences was reported by Schifferstein et al. (2013) in their study of the dynamics of multi-sensory and emotional experience of a food product. The results showed that ratings for satisfaction and pleasant surprise tended to be lowest during the buying stage. Fascination and boredom ratings tended to decrease gradually over the course of the experiment. At the purchase stage, preexisting attitudes and stereotypes toward the product group seemed to play a major role in affective reactions, while in the other stages, when olfaction and taste were actively involved, participants' emotional judgments reflected mainly their direct sensory experience. The most striking dynamics was demonstrated by the emotion of pleasant surprise: participants commented that they did not expect the product to smell and taste so good. However, the positive impact of actual experience was not persistent: at the repurchase stage, the emotion ratings returned to the same level as in the original buying stage. Apparently, people do not change their attitudes toward foods after a single positive experience.

Affective responses to a product can also differ between people. Experience is not a property of the product but the outcome of human-product interaction, and therefore is dependent on user characteristics. People can differ in their motives, abilities, preferences, goals, etc., and thus in their affective responses to a product. Desmet, Hekkert, and Hillen (2004) found a correlation between personal life values (like security, challenge, and family life) and emotional responses elicited by automotive designs. The relationship between product experience and values is particularly interesting in the context of cultural studies, because values are often seen as key determinants of culture (see Williams, 1961). Kim and Lee (2005) found cross-cultural differences in responses to mobile phone interface designs. Similarly, in a study on emotional responses elicited by automotive design, Desmet, Hekkert, and Jacobs (2000) found differences in emotional responses both between and within cultures.

Desmet and Hekkert (2007) propose using the appraisal theory of emotions (Arnold, 1960; Scherer, 2001) to account for individual and cultural differences in product emotions. According to this theory, an emotion is elicited by an evaluation (appraisal) of an event or a product as potentially beneficial or harmful to an individual (Desmet, 2002). It is the interpretation of an event or a product, rather than the event itself, which causes the emotion. An emotion is the result of an automatic and unconscious cognitive process (Lazarus, 1991). Because appraisals mediate between products and emotions, different individuals who

appraise the same product in different ways will experience different emotions (Desmet & Hekkert, 2007).

For instance, when it comes to unknown foods, some people, food neophobics, see novel or unfamiliar foods as a threat and react negatively to these products, while others, food neophilics, perceive unusual foods in a positive light and embrace situations involving new foods (Veeck, 2010). Fenko, Leufkens, and van Hoof (2015) investigated how advertising slogans could influence affective responses to a new product for these two groups of consumers. The results showed that for neophilics, the slogan conveying newness increased positive affective responses toward the product. However, for neophobics, the slogan stressing familiarity of the new product did not increase product attractiveness.

Schifferstein (2015) suggests that design approaches combining positive and negative emotions can lead to inspiring concepts that generate engaging food experiences. Although people are likely to buy products mainly for the positive emotions they elicit (e.g., satisfaction, joy, amusement), successful design strategies may nevertheless also incorporate negative emotions. Fokkinga and Desmet (2013) proposed a design approach based on rich experience qualities, derived from combining a positive with a negative emotion. For instance, to make people more aware of nutritional information in supermarkets, a designer used the combination of fascination and disgust. The resulting concept is a digital nutritional assistant for smartphones (see Fig. 18.7). When the user starts shopping, a cartoon character is displayed on the phone, which changes in shape according to the products the user puts in the cart. For instance, selecting many fatty foods will make the character look obese, selecting items with much protein will make the character look more muscular, while picking low-calorie foods will make it look slimmer.



FIGURE 18.7 A digital nutritional assistant for smartphones. (From Fokkinga, S., Desmet, P.M.A. (2013). Ten ways to design for disgust, sadness, and other enjoyments: A design approach to enrich product experiences with negative emotions. *International Journal of Design*, 7, 19–36.)

3.2.3 Cognitive Product Experience

No matter how pleasant and enjoyable the sensory properties of a product are, the decision to buy and use the product is also influenced by symbolic meanings connoted by such attributes. A smooth surface may feel pleasant on the skin, for instance, but in terms of meaning portrayal it may express softness and femininity, something that may, depending on a target group, not be a desired attribute.

In addition to abstract product features, meanings or associations connoted by brand names, product logos, and price information can also have a strong influence on affective and sensory product experience. In one of the classic studies (Allison & Uhl, 1964), consumers who drank beer with visible brands judged those beers as highly variable in their taste and preferred beers with their favorite brand label, whereas consumers who drank unbranded beers tended to rate them all as tasting similar to one another. In a 2006 investigation, Lee, Frederick, and Ariely (2006) asked participants to drink a glass of a commercially available beer and a glass of their own “MIT brew,” which consisted of the same beer with the addition of one ingredient—balsamic vinegar. Before people learned that the MIT brew had vinegar, they liked the beer just fine. But when they knew about the vinegar, the beer was perceived as repulsive. Another striking example of the symbolic power of product labels was demonstrated by Rozin, Millman, and Nemeroff (1986). They asked participants to take new glasses from a box delivered by the manufacturer, and to apply paper stickers to each glass, containing the text: “Cyanide, Poison.” Even after the subjects themselves labeled a glass with the stickers, they exhibited an unwillingness to drink from it.

The impact of brand and price information on product experience is powerful enough to be observed in brain imaging studies. McClure et al. (2004), for example, asked participants who preferred Coke to Pepsi to drink Coke and Pepsi; participants preferred Coke, but only when they knew it was Coke. The analysis of fMRI images revealed that these preferences were reflected by recruitment of brain areas involved in the processing of reward. In a similar investigation, Plassmann, O’Doherty, Shiv, and Rangel (2008) asked participants to taste one wine several times but told them that the wine was either cheap or expensive. Consumption of “higher-priced” wines was related to greater activity of reward areas in the brain. In a field study, Shiv, Carmon, and Ariely (2005) showed that people who had caught colds rated their cold remedies as more effective if they had paid full price for them. Another investigation demonstrated similar placebo effects for analgesic pills: participants who were told the pill had been discounted were unable to tolerate as much physical pain as those who were told the pill was not discounted (Waber, Shiv, Carmon, & Ariely, 2008).

3.3 Semiotic Perspective: Symbolic Product Meaning

Most people will be familiar with the aphorism, “Sometimes a cigar is just a cigar,” attributed (most likely falsely) to Sigmund Freud. Irrespective of whether the founder of psychoanalysis indeed said this phrase, it still captures the essence

of what can be described as the symbolic meaning of products. Products, of course, are physical objects that serve some practical purpose. Sometimes “product meaning” refers to this practical usage of a product, also known as “functional meaning.” However, people also use physical objects (including industrial products) as symbols that represent something else. A cigar can represent male sexual desire; a luxury car can represent the social status of its owner; an engagement ring represents an affective relationship between two people.

A considerable number of studies have demonstrated the increasing importance of symbolic meaning with respect to consumer decision-making and the formation of brand impressions (Bloch, 1995; Childers & Jass, 2002; Creusen & Schoormans, 2005; Karjalainen, 2007). For instance, Creusen and Schoormans (2005) showed that, apart from bringing esthetic delight, for consumers the most important function of a product’s appearance is the portrayal of symbolic meanings. This importance of symbolic meaning can be understood, in part, by the notion that products are an important means of self-expression and identity formation (e.g., Belk, 1988). In addition, symbolic meanings exemplified by consumer products are important with respect to brand image perceptions (Bloch, 1995; Karjalainen, 2007). Consumer perceptions of the brand “Apple,” for instance, are to some extent informed by symbolic meanings connoted through the visual appearances of branded products such as the iPod and the iMac.

Even meaningless words can trigger certain symbolic associations. This phenomenon is known as *sound symbolism*, i.e., the direct link between a sound and a meaning. In the early experiments, Köhler (1929) asked people to match the meaningless nonwords “maluma” and “takete” to abstract shapes. The results demonstrated that rounded, cloud-like shapes were matched with the soft sounding “maluma,” while spiky, star-like shapes were matched to the sharp sound of “takete”. Since then, sound symbolism has been further examined in a variety of contexts and languages. Sound symbolism helps consumers to form product expectations based on unfamiliar brand names. A 2016 study (Fenko, Lotterman, & Galetzka, 2016) investigated the effects of unfamiliar brand names (“Asahi” vs. “Ramune”), package shapes (round vs. angular), and product types (muesli cookie vs. butter cookie) on product evaluation, taste expectations, and purchase intention (Fig. 18.8). The results showed that congruent combinations of product shape and brand name (round “Ramune” cookie) were

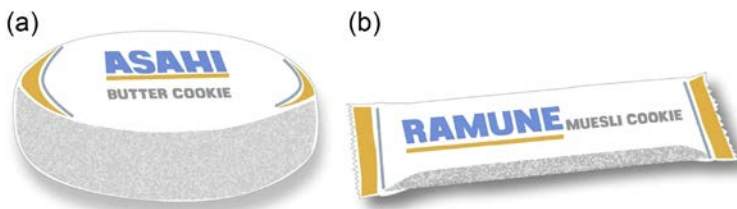


FIGURE 18.8 Examples of products used in the experiment on sound symbolism. (a) Asahi butter cookie (round package). (b) Ramune muesli cookie (angular package).

preferred to incongruent combinations. Furthermore, the congruent combinations (“Ramune” butter cookie and “Asahi” muesli cookie) were expected to taste better and were more likely to be purchased compared to incongruent combinations. These results suggest that congruency between the type of product, the brand name, and the package design is important for creating a successful product design and branding. As discussed earlier, congruence may be important because it facilitates information processing. That is, when different features of products match rather than mismatch, it is easier for consumers to form a coherent impression of the product.

3.3.1 Embodied Metaphors and Grounded Cognition

It is sometimes difficult to make a distinction between sensory and symbolic components of product experience, because almost any sensory property of a product also has a figurative meaning. Sensory terms that describe physical properties of things (such as warm, cold, heavy, sweet, bitter, etc.) also describe some psychological qualities. In cognitive linguistics, sensory metaphors (such as “knowledge is vision,” “understanding is grasping”) are viewed as fundamental to language, thought, and experience (Lakoff & Johnson, 1980; Sweetser, 1990).

Embodied cognition theory (Lakoff & Johnson, 1980) states that thought about abstract domains (e.g., morality, justice) is guided by the schematic and inferential structures of relatively concrete domains (e.g., cleanliness, balance), which involve direct bodily experience with the physical world. The rise of the embodied cognition framework within linguistics and the cognitive sciences has given this topic widespread attention (Barsalou, 2008; Gibbs, 1994; Johnson, 1987). Various authors have used the term “embodiment” to emphasize that knowledge emerges from being in a world that is inseparable from our bodies and body–world interactions (Varela, Thompson, & Rosch, 1991).

Most accounts of embodied cognition assume that the physical experience is part of the representation of a symbolic concept (e.g., Zhang & Li, 2012). For instance, Zhong and Leonardelli (2008) showed that people who were instructed to think of an episode in which they felt socially excluded gave lower estimates of room temperature compared to participants who recalled an inclusion episode in which they were socially involved with others. The embodied basis of such findings can be traced to early-life social interactions in which physical warmth is equated with intimacy and belongingness, for example, a mother holding her newborn close to her own body.

Exploring the metaphorical meaning of hardness, Ackerman, Nocera, and Bargh (2010) had participants imagine shopping for a new car, making an offer to the dealer, being rejected, and having to make a second offer. Participants were sitting in a hard wooden chair or a soft cushioned chair. Those sitting in a hard chair receded less from the first to the second offer. Follow-up work (Cherkasskiy, Song, Malahy, & Bargh, 2012) also found that sitting in a hard

rather than a soft chair while reading criminal scenarios led people to recommend harsher sentences.

In product design, embodiment has been used to explain the relationships between product features such as shape, color, logo, and typeface, on one hand, and symbolic or affective meanings on the other (Van Rompay & Ludden, 2015). In a 2006 study, for instance, Zhang, Feick, and Price (2006) showed that rounded logos are generally perceived as more harmonious and less aggressive than angular logos. In line with the writings of Arnheim (1974), they accounted for this relation by arguing that, on a perceptual level, angular shapes represent a confrontation between a stimulus and its surroundings, hence the aggressiveness connotation, whereas rounded shapes present no such clash between stimulus and surroundings (cf. Bar & Neta, 2006).

In line with these findings, Becker, Van Rompay, Schifferstein, and Galetzka (2011) displayed a lemon yogurt dessert in either an angular-shaped or a circular-shaped package (see Fig. 18.9). Next, participants tasted an identical yogurt from a (neutrally shaped, white) sample cup. Results showed that shoppers at a supermarket (where the study took place) rated yogurt taste as more intense when associated with the angular package. Importantly, however, this effect was dependent on design sensitivity (a scale developed by Bloch et al., 2003); only participants sensitive to (subtle) design influences discriminated between the two package variants.

In a follow-up study, Van Rompay, Finger, Saakes, and Fenko (2016) applied the angular/rounded dimension to the haptic level (i.e., touch) by printing three-dimensional sample cups with either angular or rounded surface patterns (see Fig. 18.10). This time, participants tasted a product (a sweet hot chocolate drink



FIGURE 18.9 Stimulus materials (selection). (From Becker, L., Van Rompay, T. J., Schifferstein, H. N., & Galetzka, M. (2011). Tough package, strong taste: The influence of packaging design on taste impressions and product evaluations. *Food Quality and Preference*, 22(1), 17–23.)



FIGURE 18.10 Surface pattern variants (Van Rompay et al., 2016).

or a bitter hot coffee) from one of the two cups. Again, people who drank from the cup with the angular-shaped surface pattern rated the taste as more intense. Results also showed that participants rated the drink as more bitter when tasted from the cup with the angular surface pattern, whereas they rated the drink as sweeter when tasted from the cup with the rounded surface pattern.

Importantly, however, people liked the taste and the overall product better when surface texture and drink type were congruent. Hence, the sweet chocolate was preferred when coupled to the rounded surface pattern, whereas the bitter coffee was liked better when associated with the angular surface pattern. These findings confirm the earlier discussed finding that design elements should be perceived as appropriate to elicit favorable consumer experiences.

Additionally, these findings highlight the suitability of the embodied cognition framework. The embodied basis of angularity effects can be traced to physical, tactile interactions in which angular (as opposed to rounded) objects or surface patterns make for a more intense and sharp experience on our skin, which subsequently translates to taste evaluation.

Likewise based on the embodiment framework, Van Rompay, Hekkert, Saakes, and Russo (2005) demonstrated a relation between a product's relative height and perceived dominance, explaining this finding in terms of *image schemas*: being in a high position is associated with greater control (e.g., visual control over those below) or power (e.g., objects are easier to manipulate from above). Because of this association in everyday experience between verticality interactions and experienced affect (i.e., feeling dominant, proud, or in control), variations in relative (product) height influence the extent to which products are perceived as expressive of related meanings (e.g., pride or dominance).

Containment is another example of an image schema. Being inside a closed space such as one's office, house, or car is generally correlated with experiencing security and room for personal expression. At the same time, containers limit our freedom of movement and block our view to what is outside the container. Hence, containment is also associated with expressive qualities such as

constraint and suffocation. In line with this argument, [Van Rompay, Hekkert, Saakes, and Russo \(2005\)](#) showed that a closed jug with a narrow opening is more readily perceived as secure and constraining compared to an open jug.

On a haptic level, [Jostmann, Lakens, and Schubert \(2009\)](#) propose that people tend to equate heaviness with importance, a coupling also apparent in language use, for example, “a weighty issue” or “an issue not to be taken lightheartedly.” They had participants provide judgments of importance while they held either a heavy or a light clipboard. Holding a heavy clipboard increased, among other things, judgments of monetary value. Such findings concur with the skepticism people may feel when holding lightweight, technologically advanced gadgets or devices such as a mobile phone. Such skepticism may relate to associations such as cheapness, flimsiness, or vulnerability, triggered by a literal lack of substance. A 2014 study ([Van Rompay, Verdenius, Okken, & Pruyn, 2014](#)) shows that excessively lightweight mobile phones might harm value perceptions and, consequently, lower price expectations. Similarly, [Fenko, Heiltjes, and van den Berg-Weitzel \(2016\)](#) demonstrated symbolic congruence between the weight of beer bottles and certain brand values. Heavy bottles were perceived as representing *excellence*, *authenticity*, and *authority*, while light bottles were associated with *dynamic* and *accessible* brands. These studies illustrate the embodied associations between weight and importance, with heavier objects generally being more important and valuable.

Decisions on product weight, material conductivity, and texture selection are common aspects of design processes. Knowledge about how such design decisions influence consumer experience is important for designers ([Janlert & Stolterman, 1997](#); [Karana, 2009](#)). For instance, in selecting a material with low heat conductivity, feeling relatively warm at average room temperature could inspire sensations of social, psychological warmth among users.

3.4 Managers’ Perspective: Consumer Satisfaction

The conceptual framework of consumer satisfaction is often used in the context of brand management and product development. Numerous studies have demonstrated that consumer satisfaction is determined by product design and brand strategy ([Henard & Szymanski, 2001](#); [Montoya-Weiss & Calantone, 1994](#)). Brands with the capability to produce novel designs perform better than firms with relatively inferior capabilities ([Hertenstein, Platt, & Verryzer, 2005](#); [Perks et al., 2005](#)). Satisfied consumers exhibit considerable brand loyalty and a greater willingness to pay higher prices for products and services ([Anderson & Sullivan, 1993](#)). They do not immediately switch their preferences to a lower-priced competitor when faced with a price increase ([Herrmann, Huber, & Braunstein, 2000](#)).

Consumer (dis)satisfaction is the outcome of a complex information-processing process, which essentially consists of a desired–actual comparison of the consumers’ experience with a purchased product or service and their

expectations with regard to the fitness of this product or service for its intended purpose (Herrmann et al., 2000). The congruence or divergence yielded by this comparison between the perceived product quality and the anticipated quality is expressed as the consumer's (dis)confirmation. Of the many attempted definitions, the one best suited to the purposes of this work is the one put forward by Anderson: "...consumer satisfaction is generally construed to be a post-consumption evaluation dependent on perceived quality or value, expectations and confirmation/disconfirmation—the degree (if any) of discrepancy between actual and expected quality ..." (Anderson, 1994, p. 20).

Because these judgments are important indicators of future purchasing behavior, a company can improve its product by analyzing consumer satisfaction. Herrmann et al. (2000) described an approach developed by German Rail to analyze and improve consumer satisfaction with the InterCity line between Frankfurt and Paris. The approach consisted of three steps. First, the wishes of potential and actual customers with regard to the quality of service on the InterCity trains were determined, using various methods, such as the repertory grid approach, the laddering interview, and the content analysis. The next step was to transform these abstract customer conceptions into concrete quality attributes. This task was accomplished by means of a conjoint analysis on the basis of the information acquired at the previous step. Finally, the fitness of the offered services for their intended purpose was examined, with particular emphasis on satisfaction measurement (Herrmann et al., 2000).

Townsend, Kang, Montoya, and Calantone (2013) investigated the relationship between the components of product design and consumer satisfaction. A longitudinal model based on objective measures of two critical design factors, form and function, was tested with a data set developed from models available on the US automotive market from 1999 to 2007; it included 16 firms, 32 brands, and 137 products. The findings indicated that a similar design was perceived differently dependent on brand association. For instance, when evaluating the form and function of luxury brands, consumers paid more attention to individual design components, while in the mass-market segment consumers valued only the well-coordinated form and function of vehicles. The authors suggest that the reason for this difference is that luxury brands may already be providing the systematic designs consumers prefer, and therefore consumers are more sensitive to individual design characteristics. Mass-market brands, though, benefit from developing a gestalt approach to new product design.

A lot of qualitative and quantitative methods are used to increase consumer satisfaction, including the repertory grid approach, the laddering interview, content analysis, surveys, and conjoint analysis. One of the relatively less known methods originated from Japan in the 1980s and is known as *affective design*, or *Kansei engineering*. The method is becoming more and more popular in Western countries as the method used to study the interactions between human emotions and design of products, so as to improve consumer satisfaction (Chang, 2008). Basically, affective design (i.e., Kansei engineering) is a

methodology that translates consumer affective requirements into product design elements (Nagamachi, 2002). In affective design, affection (or “Kansei” in Japanese) refers to consumer affective impressions or feelings about a product (Nagamachi, 1995). It may be evoked by such attributes as product form, style, color, function, and price, and is affected by consumer emotions and personal sense of values (Lee, Harada, & Stappers, 2002). Since its inception, affective design has received much attention in both academia and industry and has found many successful applications in product development, such as the automobile industry, construction machines, electrical appliances, costumes, and household products (Nagamachi, 1999).

Ikeda, Nagai, and Sagara (2004) proposed the Food Kansei Model to correlate the physical properties of food and food perception. The model allows one to quantitatively evaluate personal gustatory experiences during eating behavior to optimize product design and manufacturing processes. The model has been applied to investigate the relationships between instrumental and sensory data of bottled green tea beverages (Ikeda et al., 2004), sesame-flavored dressings (Ikeda et al., 2006), Danish pastries (Shibata, Araki, & Sagara, 2008), prepackaged chilled espresso beverages (Michishita et al., 2010), and ready-to-drink coffee beverages (Akiyama et al., 2012).

Kansei data are usually obtained from consumers through survey. More specifically, a collection of samples (design alternatives) of the product to be developed is presented to selected consumers and their appreciation of (psychological feelings toward) each of the design alternatives is recorded using semantic differential (SD) scales. Kansei uses scales that express the typical feelings of consumers about a product. For example, typical scales may include “stylish,” “compact,” and “luxurious,” when consumers evaluate the appearance of a mobile phone. The image of a product is quantified by the rating scores attained by each of the SD scales. Affective design enables designers to identify product features that can meet consumer affective needs and thus improve consumer affective satisfaction with more appealing products.

4. CONCLUSIONS AND IMPLICATIONS

Understanding consumer responses to design is crucial for successful product design. In this chapter, we have discussed consumer responses to product design from four different perspectives.

The designers’ perspective makes a distinction between product form (esthetic properties) and function (utilitarian properties). Multiple studies have been performed to understand the formation of the esthetic impression and consumer responses to esthetic product properties (e.g., novelty, originality, and familiarity). Esthetic appreciation has been understood in terms of processing fluency: familiar or congruent stimuli that are processed more fluently and are perceived as more beautiful. Studies show that esthetic designs trigger positive consumer responses, including a desire to buy the product and a willingness

to pay a higher price for it. However, for some product categories esthetic features seem to induce negative evaluations of functional properties (Hoegg et al., 2010).

The consumer perspective is focused on product experience, including sensory, affective, or cognitive reactions that are elicited by consumer–product interactions (Hekkert & Schifferstein, 2008). Empirical studies emphasize the complex relationships between these three components of product experience. Sensations of different modalities (vision, touch, audition, olfaction, and taste) are integrated into multisensory product experiences (e.g., freshness, warmth, or noisiness) that are closely connected to affective reactions (Fenko & Schifferstein, 2012). Cognitive experience comprises consumer attitudes, beliefs, and values, and can influence affective and sensory product experience, which is illustrated by the effects of brand and price information on taste evaluation and product enjoyment.

The semiotic perspective is related to the symbolic meaning of product design (Van Rompay et al., 2009), which can be broadly understood as associations between the sensory properties of a product (e.g., material, shape, color, logo, and typeface) and more abstract qualities such as elegance, aggressiveness, friendliness, or social importance. Many of these associations can be understood in terms of embodiment and grounded cognition theory (Lakoff & Johnson, 1980). We have discussed some applications of this theory in product design, including sensory metaphors and image schemas.

The managerial perspective is focused on consumer satisfaction, i.e., the evaluation of a purchased product that depends on perceived quality or value, consumer expectations, and confirmation or disconfirmation of these expectations. Consumer satisfaction is an important goal of brand management and product development, because satisfied consumers exhibit considerable brand loyalty and a greater willingness to pay higher prices for products. We have discussed some of the methods used to measure and improve consumer satisfaction, including Kansei engineering.

Together, these four perspectives on product design help us to understand the complexity of consumer responses to design and form the foundation for an integrated framework of consumer-driven design. However, studies that try to integrate different perspectives on consumer-driven design are scarce. The majority of the empirical research in the area suffers from a lack of theoretical explanation. For instance, as of this writing, a lot of studies are looking at the effects of different sensory attributes of products (i.e., colors, materials, shapes, etc.) on consumer experience and esthetic appreciation of products.

However, multiple demonstrations of specific effects are no guarantee for a better understanding of the phenomenon under discussion. For instance, the relationships between shape angularity and a wide variety of consumer responses, including product preference (Bar & Neta, 2006), food intensity ratings, and specific meaning portrayals (e.g., perceiving a product as *tough* or *masculine*; Becker et al., 2011) have been demonstrated repeatedly. Some of these results

are well explained by the embodied cognition framework. For instance, the finding that angular packaging shapes contribute to a “tough” expression, and subsequently can inspire perceptions of food contents as “strong” in taste may be understood by reflecting on bodily interactions with angular objects, which make for an intense or sharp impression on our skin. However, the question of why angularity also contributes to the evaluation of food contents as, for instance, bitter (Ngo, Misra, & Spence, 2011) is less well understood.

In sum, in-depth studies incorporating measures indicative of the underlying (psychological) processes are warranted from both a scientific perspective and a managerial perspective. In this chapter, we have tried to emphasize such possible mechanisms (e.g., processing fluency and embodied cognition) that can help to explain certain empirical phenomena in the area of consumer-driven design. Further research is needed to address alternative theoretical explanations of existing phenomena and to compare the explanatory power of existing theoretical models in various research contexts and for various consumer groups.

Finally, throughout this chapter, the importance of carefully considering product type was stressed. For instance, we argued that a strong focus on esthetics may backfire when considering highly functional products. Likewise, in discussing the influence of material surface patterns, we showed that these should be product-congruent when the aim is to enhance consumer appreciation. Hence, in addition to insights into consumer needs, a thorough understanding of the product under consideration and its core qualities to be communicated and enhanced (whether it is a product image-related quality such as toughness for durables, or a sensory attribute such as bitterness or sweetness for food products) is required for successful application of the insights discussed in this chapter. Especially, with the ever-growing means for experimentation and differentiation provided by technologies such as three-dimensional printing, it is all the more important to start from sound insights into the processes involved rather than to adopt a “trial-and-error” approach. It is hoped that this chapter contributes to such an understanding and will inspire theory-informed follow-up studies.

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About the Editors

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WOODHEAD
PUBLISHING

An imprint of Elsevier
elsevier.com/books-and-journals

ISBN 978-0-08-101743-2



9 780081 017432