Time-Dependent Measures of Perception in Sensory Evaluation

Editors
Joanne Hort, Sarah E. Kemp
and Tracey Hollowood

WILEY Blackwell

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Sensory Evaluation

The series is intended as a follow-up to *Sensory Evaluation: A Practical Handbook*, published in May 2009. This book was focused on the practical aspects of sensory testing, presented in a simple, 'how to' style for use by industry and academia as a step-by-step guide to carrying out a basic range of sensory tests. In-depth coverage was deliberately kept to a minimum. The series is intended to give theoretical background, more complex techniques and in-depth discussion on application of sensory evaluation that were not covered in the *Practical Handbook*. However, the series will seek to maintain the practical approach of the handbook and chapters will include a clear case study with sufficient detail to enable practitioners to carry out the techniques presented.

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To Campbell, Emma and Lara
To George, Elizabeth, George and William
To Mike, Holly and Socks

Contents

Notes on Editors

Joanne Hort, BEd (Hons), PhD, CSci, FIFST, RSensSci, is the SABMiller Chair of Sensory Science at the University of Nottingham. Initially, Professor Hort studied food technology and began her career in teaching. However, she returned to university to receive her doctorate concerning the modelling of the sensory attributes of cheese from analytical and instrumental measures in 1998. As a lecturer at Sheffield Hallam University, she carried out sensory consultancy for local industry, developed a sensory programme at undergraduate level and oversaw the installation of new sensory facilities before being appointed as Lecturer in Sensory Science at the University of Nottingham in 2002. There, she established the University of Nottingham Sensory Science Centre, which is now internationally renowned for both its sensory training and research into flavour perception. She obtained her Chair in 2013 and developed a passion to understand the complexity of beer flavour. Her multidisciplinary approach combining analytical, brain imaging and sensory techniques provides rich insight into multisensory interactions, individual variation and temporal changes in flavour perception, and the emotional response to sensory properties leading to over 65 publications. She leads the International Centre for Brewing Science group at Nottingham, which has an international reputation for its brewing research and innovative postgraduate training programmes. Joanne sits on the editorial board for *Food Quality and Preference*, *Chemosensory Perception* and the *Journal of American Society of Brewing Chemists*. She is a Fellow of the Institute of Food Science and Technology and member of the American Society of Brewing Chemists and Institute of Brewers and Distillers. She is a founder member and past Chair of the European Sensory Science Society and a founder member, past Chair and examiner for the IFST's Sensory Science Group.

Sarah Elizabeth Kemp, BSc (Hons), PhD, CSci, FIFST RSensSci, is a chartered sensory and consumer science professional with more than 30 years of experience in academia and industry. Dr Kemp gained a BSc in Food Technology in 1986 and a PhD in Taste Chemistry in 1989 from the Food Science and Technology Department at the University of Reading, UK. In 1990, she did a postdoctoral research fellowship in sensory science at the Monell Chemical Senses Centre in Philadelphia, USA. Dr Kemp has held numerous positions in industry, including Manager of Sensory Psychology (US) and Director of European Consumer and Marketing Research (France) in the Fragrance Division at Givaudan, Product Area Leader and Sensory Science Leader in Foods Consumer Science at Unilever Research, Colworth, UK, Head of Global Sensory and Consumer Guidance at Cadbury Schweppes, UK, and Director of Sensory and Consumer Services at Reading Scientific Services Limited, UK. Dr Kemp has also set up and run her own consultancy service and catering company. She has written numerous scientific articles in the field of sensory evaluation, has provided sensory

training courses, including lecturing on the European Masters Course in Food Science, and has worked on bodies developing standards in sensory evaluation, including the British Standards Institute and ASTM International. She is a founder member, past Chair and examiner for the Sensory Science Group of the Institute of Food Science and Technology, as well as being a member of other professional sensory societies. Her other activities include Governor of East Kent College, UK.

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Tracey is currently Director of Sensory and Consumer Research for Sensory Dimensions (Nottingham) Ltd in the UK. She has over 25 years experience in academia and industry; she worked at Nottingham University for 10 years during which time she achieved her doctorate investigating perceptual taste-texture-aroma interactions. She established the UK's first Postgraduate Certificate in Sensory Science and designed and managed the University's prestigious Sensory Science Centre. Her research focused on psychophysical studies, interactions in sensory modalities and fundamental method development. She has over 20 peer reviewed publications; has run numerous workshops and delivered oral presentations to many international audiences including at the Pangborn Sensory Science Symposia 2015 in Gothenburg. She has participated in the organisation of seven international symposia, including International Symposium of Taste 2000 and Pangborn 2005 in Harrogate. Tracey is a previous chair of the Institute of Food Science and Technology (IFST) Midland branch and the Professional Food Sensory Group (PFSG), now the Sensory Science Group (SSG).

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Preface to the Series

Sensory evaluation is a scientific discipline used to evoke, measure, analyse and interpret responses to products perceived through the senses of sight, smell, touch, taste and hearing (Anonymous, 1975). It is used to reveal insights into the way in which sensory properties drive consumer acceptance and behaviour, and to design products that best deliver what consumers want. It is also used at a more fundamental level to provide a wider understanding of the mechanisms involved in sensory perception and consumer behaviour.

Sensory evaluation emerged as a field in the 1940s. It began as simple 'taste testing' typically used in the food industry for judging the quality of products such as tea, cheese, beer, and so on. From the 1950s to the 1970s, it evolved into a series of techniques to objectively and reliably measure sensory properties of products, and was typically used to service quality assurance and product development. Through the 1980s and 1990s, the use of computers for data collection and statistical analysis increased the speed and sophistication of the field, so that sensory, consumer and physicochemical data could be combined to design products that delivered to consumer needs.

Today, sensory evaluation is a sophisticated, decision-making tool that is used in partnership with marketing, research and development and quality assessment and control throughout the product lifecycle to enable consumer-led product design and decision making. Its application has spread from the food industry to many others, such as personal care, household care, cosmetic, flavours, fragrances and even the automotive industry. Although it is already widely used by major companies in the developed market, its use continues to grow in emerging markets, smaller companies and new product categories, as sensory evaluation is increasingly recognised as a necessary tool for competitive advantage.

The field of sensory evaluation will continue to evolve and it is expected that faster, more flexible and more sophisticated techniques will be developed. Social networking tools are already transforming the way research is undertaken, enabling direct and real-time engagement with consumers. The use of sensory evaluation by marketing departments will continue to grow, particularly in leveraging the link between product sensory properties and emotional benefits for use in branding and advertising. Advances in other fields, such as genomics, brain imaging, and instrumental analysis, will be coupled with sensory evaluation to provide a greater understanding of perception.

Owing to the rapid growth and sophistication of the field of sensory evaluation in recent years, it is no longer possible to give anything but a brief overview

of individual topics in a single general sensory science textbook. The trend is towards more specialised sensory books that focus on one specific topic, and to date, these have been produced in an ad-hoc fashion by different authors/editors. Many areas remain uncovered.

We, the editors, wanted to share our passion for sensory evaluation by producing a comprehensive series of detailed books on individual topics in sensory evaluation. We are enthusiastic devotees of sensory evaluation, who are excited to act as editors to promote sensory science. Between us, we have over 70 years of industrial and academic experience in sensory science, covering food, household and personal care products in manufacturing, food service, consultancy and provision of sensory analysis services at local, regional and global levels. We have published and presented widely in the field; taught workshops, short courses and lecture series; and acted as reviewers, research supervisors, thesis advisors, project managers and examiners. We have been active in many sensory-related professional bodies, including the Institute of Food Science and Technology Sensory Science Group, of which we are all past Chairs, the European Sensory Science Society, of which one of us is a past Chair, the Institute of Food Technologists, the British Standards Institute and ASTM International, to name but a few. As such, we are well placed to have a broad perspective of sensory evaluation, and pleased to be able to call on our network of sensory evaluation colleagues to collaborate with us.

The book series *Sensory Evaluation* covers the field of sensory evaluation at an advanced level and aims to:

- be a comprehensive, in-depth series on sensory evaluation
- cover traditional and cutting-edge techniques and applications in sensory evaluation using the world's foremost experts
- reach a broad audience of sensory scientists, practitioners and students by balancing theory, methodology and practical application
- reach industry practitioners by illustrating how sensory can be applied throughout the product life cycle, including development, manufacture, supply chain and marketing
- cover a broad range of product applications, including food, beverages, personal care and household products.

Our philosophy is to include cutting-edge theory and methodology, as well as illustrating the practical application of sensory evaluation. As sensory practitioners, we are always interested in how methods are actually carried out in the laboratory. Often, key details of the practicalities are omitted in journal papers and other scientific texts. We have encouraged authors to include such details in the hope that readers will be able to replicate methods themselves. The focus of sensory texts often tends to be food and beverage products assessed using olfaction and taste. We have asked authors to take a broad perspective to include non-food products and all the senses.

The book series is aimed at sensory professionals working in academia and industry, including sensory scientists, practitioners, trainers and students; and

industry-based professionals in marketing, research and development and quality assurance/control, who need to understand sensory evaluation and how it can benefit them. The series is suitable as:

- reference texts for sensory scientists, from industry to academia
- teaching aids for senior staff with responsibility for training in an academic or industrial setting
- course books, some of which to be personally owned by students undertaking academic study or industrial training
- reference texts suitable across a broad range of industries; for example, food, beverages, personal care products, household products, flavours, fragrances.

The first book in the series, *Sensory Evaluation: A Practical Handbook* was published in May 2009. This book focuses on the practical aspects of sensory testing, presented in a simple, 'how to' style for use by industry and academia as a step-by-step guide to carrying out a basic range of sensory tests. In-depth coverage was deliberately kept to a minimum. Further books in the series cover the basic methodologies used in the field of sensory evaluation: discrimination testing, descriptive analysis, time-dependent measures of perception and consumer research. They give theoretical background, more complex techniques and in-depth discussion on application of sensory evaluation, whilst seeking to maintain the practical approach of the handbook. Chapters include clear case studies with sufficient detail to enable practitioners to carry out the techniques presented. Later books will cover a broad range of sensory topics, including applications and emerging trends.

The contributors we have selected are world-renowned scientists and leading experts in their field. Where possible, we have used originators of techniques. We have learned a lot from them as we have worked with them to shape each book. We wish to thank them for accepting our invitation to write chapters and for the time and effort they have put in to making their chapters useful and enjoyable for readers.

We would also like to thank our publisher, Wiley Blackwell, and particularly extend our thanks to David McDade, Andrew Harrison and their tea for seeing the potential in this series and helping us bring it to fruition. We would also like to thank the anonymous reviewers of the series for their constructive comments.

We hope you will find the *Sensory Evaluation* book series both interesting and beneficial, and enjoy reading it as much as we have producing it.

Joanne Hort
Sarah E. Kemp
Tracey Hollowood

Reference

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Preface

Perception is a dynamic process, changing both in the short and long term and in several different ways. A need to understand such changes and their implications for sensory and consumer studies was the motivation for this book. The sensory properties of food and beverages alter quite considerably as they are manipulated and swallowed in the oral cavity, the feel of moisturiser changes as it is massaged into the skin and the perfume associated with air fresheners and fabric softeners fades, and can change in nature, as time passes. Furthermore, our physiology has evolved to react to changes in our environment as opposed to things that are constant via the mechanism of adaptation. Repeated exposure to the same stimulus results in a drop in perceived intensity of that stimulus, effects other sensations via interactions between and within the senses.

Interestingly, it is not just the perception of sensory properties that are time dependent. Our affective response to the continued consumption of the same food can also diminish over short time periods; for example, the course of a meal, owing to an inbuilt biological mechanism known as sensory-specific satiety, which helps promotes the intake of a more varied diet. It is also evident that product preferences are not stable over time and this affects our food choice and purchase behaviours. Our perceptual experiences are held within our sensory memory and they have a key role in determining product expectations and choice behaviours.

The last 60 years have seen many investigations into the temporal elements of perception, particularly taste and flavour perception, but at the current time there is no book which brings together current knowledge on time-dependent measures of sensory perception. Hence, we have taken the opportunity, as part of our book series on 'sensory evaluation', to devote a whole textbook to this important topic for the sensory scientist. Each chapter provides insights into the scientific background of the subject matter before providing descriptions and evaluations of relevant methodologies, practical tips and case study examples.

The book itself is divided into five sections: Section 1: Introduction; Section 2: Physiological and psychological aspects of time-dependent sensory perception; Section 3: Techniques; Section 4: Applications; Section 5: Summary.

Following on from a general introduction to the measurement of time-dependent perception in Section 1, Section 2 is devoted to chapters written by experts in the field which reflect on the physiological and psychological aspects influencing time-dependant perception. An understanding of these factors is key to the development of sensory methods and test protocols as well as in the

interpretation of sensory data. The first chapter in this section provides an understanding of salivation and mastication, processes which have a profound effect on the perceived sensory properties of a food. The following chapter not only delivers an overview of the processes involved in sensory specific satiety but also discusses the methods that can be employed for its measurement. Chapter 4 describes the mechanisms involved and perceptual consequences of sensory adaptation. Importantly it provides valuable insights into how adaptation affects can be managed within the design of sensory studies. The final two chapters in this section come from experts in the field of memory and liking, Ep Köster and Jos Mojet. The first looks at the concept of sensory memory and the methods used to measure it, together with particularly interesting sections showing how sensory memory is central to consumer insight research and the training of sensory panels. The second looks at the vast array of factors affecting the dynamics of liking, before reviewing both the traditional and emerging methodologies available to measure changes in liking, and ends with some practical applications.

Although the need to measure temporal elements of perception in foods was recognised back in the 1930s, the first method to measure it was the time–intensity technique published by Sjostrom and Cairncross in 1953. It was adopted widely and Lee and Pangborn (1986), and Cliff and Heymann (1994) have both written reviews of its application during the last century. Other approaches capturing time-dependent elements of perception have since been developed and Section 3 is devoted to chapters which describe the now established techniques within the sensory toolbox that can capture changes in sensory properties over time. Chapter 7 provides the reader with a general overview of the considerations needed for any technique including guidelines regarding which approach to choose for a particular purpose. Chapters 8–12 then provide background on the specific techniques of discrete, continuous and dual-attribute time–intensity, temporal dominance of sensations and multiple-sample time–intensity.

Section 4 provides an overview of the application of different temporal techniques to both food and non-food products, and in flavour research. Section 5 completes the book, with an evaluation of the current situation concerning time-dependent measures of perception, recent developments and considerations for the future.

We hope you find this text a valuable addition to your sensory library and a useful guide for your time-dependent sensory investigations.

The Editors

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SECTION I
Introduction

CHAPTER 1

Time-Dependent Measures of Perception: An Introduction

Joanne Hort, Tracey Hollowood and Sarah E. Kemp

1.1 Introduction

Perception of a product is a dynamic process. This description concerning drinking beer (Bickham, 1997) is a great example outlining one of the many temporal sensory journeys encountered by consumers when interacting with products.

> From the moment the bottle is opened and the beer is poured into a glass, our ears are greeted by the hiss of escaping carbon dioxide. Our eyes are attracted by the sparkling clarity of a Pilsener, the hazy sheen of a Weizen, or the black depth of a stout. We patiently wait for the creamy head to slowly collapse, leaving wisps of Belgian lace on the sides of the glass. As we bring the beer to our lips, our nose detects the aroma of citrusy hops in an American pale ale, bittersweet chocolate in a porter, or perhaps fruity, spicy esters in a Trappist ale. Finally, we imbibe, savouring the malt, hop, and ester flavours before swallowing to let the hop alpha-acids wake the taste buds on the back of the tongue. We take another drink and swish the beer through our mouth to evaluate the body and mouthfeel. Ah, this seems like a well-made beer – but wait! What is that lingering aftertaste? Does it taste like cooked cabbage, or is it perhaps reminiscent of newly mown grass? Is that a hint of paper or leather in the background?'

Wine, chocolate, ice cream and chewing gum are all further obvious examples of food products whose sensory properties change dynamically during oral processing, but in fact all food and beverages will be warmed, mixed and manipulated to some degree in the mouth resulting in changeable sensory profiles. Of course, it is not just simply foods which exhibit temporal sensory profiles – for example, the vibrancy of lipstick, persistency of a hair dye and the intensity and nature of perfumes, cologne, air fresheners, fabric conditioners and deodorants are all attributes which also change overtime and are regarded as quality attributes by the consumer. Descriptive techniques at different time points have been widely adopted and adapted for many different types of products including foods, beverages, fragrances, cosmetics, personal care and household products.

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Edited by Joanne Hort, Sarah E. Kemp and Tracey Hollowood.

1.2 Development of Time-Dependent Techniques for Dynamic Changes in Sensory Attributes

Measures made at a single time point, such as those obtained through traditional descriptive analysis techniques (Kemp et al., 2016) require assessors, or even consumers, to make an evaluation at one time point and hence do not capture the full temporal sensory encounter. Such evaluations are likely to be an integration of the whole experience (Dijksterhuis and Piggot, 2000), or depending on the assessor or tasting protocol, specific to a certain point in time. Thus, it is not surprising that temporal methods that captured dynamic changes began to be developed alongside other sensory techniques. The need to measure attribute intensity over time was initially recognised in the literature as an important aspect of taste perception in 1937 by Holway and Hurvich (1937). In the fifties, Sjostrom (1954) began quantifying the temporal response and, over the next three decades, developments in the technique and particularly its data acquisition methods (for example: Jellinek, 1964; Meiselman, 1968; McNulty and Moskowitz, 1974; Larson-Powers and Pangborn, 1978; Lawless and Skinner, 1979; Birch and Munton, 1981; Munoz et al., 1986; Guinard et al., 1985; Lee, 1985) saw its wide application to taste and flavour perception (Cliff and Heymann, 1993). Not surprisingly, there have been several useful published reviews of the technique to which the reader is directed (Lee and Pangborn, 1986; Cliff and Heymann, 1993; and Dijksterhuis and Piggott, 2000).

Initially, time–intensity (TI) data were collected at discrete time points defined by the investigator. However, the development of chart recorders and computer programs allowed for the collection of continuous data. Nowadays, the choice between discrete and continuous TI (CTI) techniques is related to the objective of the test – for short events, CTI is ideal but for longer investigations, e.g. the intensity of fabric conditioner fragrance on laundry, judgements made at discrete well-defined time points are most effective. Chapters 8 and 9 in this text provide an updated look at developments in discrete and CTI methods, respectively, and provide guidance on specific methodological considerations and data analysis techniques. Each also provides useful case studies highlighting the effective application of these techniques.

CTI was designed to follow the perceptual intensity of a single attribute, and has been useful to investigate key product attributes, such as mint flavour in chewing gum, but it is rare for products to vary in just one characteristic over time. Methods have since been developed which track the intensity of more than one attribute, such as progressive profiling (Jack et al., 1994); the dynamic flavour profile method (DeRovira 1996), sequential profiling (Methven et al., 2010) and dual-attribute TI (DATI; Duizer et al., 1996, 1997). The last is the subject of Chapter 10.

Changes in attribute intensity are not the only changes that occur to sensory properties over time and, although TI continues to be a well-used tool in the sensory toolbox, the 21st century has seen the development of new approaches which enable other aspects of a sensory temporal profile to be explored. The most notable development has been the technique that emerged from Pascal Schlich's laboratory at INRA, Dijon, called temporal dominance of sensations (TDS; Pineau et al., 2003, 2009), recently reviewed by Di Monaco et al. (2014). Rather than focusing on single attribute intensities, this approach considers all product attributes from which the panel then identify those that are perceived to be dominant at any time during consumption. It captures data that allows the sequence of dominant sensations experienced during product interactions to be described. It is not proposed as a replacement to TI but as a complementary and different way of looking at the temporal profile experienced by the consumer over time. Chapter 11 provides a comprehensive review of the technique, aspects of data analysis and presentation and considerations relating to the practical application of the technique.

The application of the aforementioned techniques has often been restricted to single bites or sips of products but this is rarely representative of real situations where individuals consume multiple bites or sips of the product. The TDS approach has already been extended to multiple sips with success (Jappinen 2014; Zorn et al., 2014; Hort et al., 2015). Where researchers have required a fuller sensory profile of how attribute intensity for a full range of sensory characteristics evolves during repeated exposure to a product, multi-sampling TI has provided a solution. Essentially, assessors perform a series of single-attribute evaluations across multiple sips/bites of the product. This approach is the subject of Chapter 12, which contains two interesting case studies on measuring the temporal profiles of ice cream and tea.

The measurement of temporal changes in sensory attributes appears to have been re-energised in that last few years with new methods such as temporal order of sensations (TOS; Pecore et al., 2009) and temporal check-all-that-apply (TCATA; Castura et al., 2014a,b) methodologies presented at recent Sensory meetings, which are already available within some commercial data collection and analysis software programmes. Although these approaches do not have dedicated chapters in this book, they are described in the final summary chapter.

The use of time-dependent measures continues to evolve. In the early years, the focus was on development of the original TI approach, its data collection and analysis, and its application to understand fundamental elements of taste and aroma perception one attribute at a time. Developments in techniques that have enabled multiple attributes to be considered concurrently have seen broader application of the technique beyond technical understanding to much wider product development applications.

1.3 Time-Dependent Methods as Tools in Sensory Evaluation

Time-dependent methods are a distinctive subset of descriptive analysis techniques that allow the changes in the temporal sensory profile of a product to be monitored. Like all descriptive techniques, they generally provide detailed, precise, reliable and objective information concerning the sensory attributes of a product. However, uniquely, they are focused on capturing information about the dynamic changes in an attribute or attributes, whereas other descriptive techniques provide a profile of an overall impression of an attribute or an attribute at a single time point. Non-time-dependent descriptive techniques provide an overall sensory profile of the product, although sometimes temporal elements are captured by stating the stage during consumption/use at which a measure is taken – for example, initial sweetness, sweetness in the mouth, sweet aftertaste. This provides useful information and researchers should consider whether such a level of information is sufficient for their particular objectives before investing in what are often more time-consuming and costly approaches with time-dependent techniques (Lawless and Heymann, 1998). However, where detailed temporal information is needed, time-dependent approaches should be employed and can provide insightful data.

In parallel with most other descriptive techniques, time-dependent methods use humans as measuring instruments under controlled conditions (to minimise bias) in order to generate, in this case, temporal data. The length of time-dependent studies often means that fewer assessors are used, owing to the practical considerations of time and resource. In most time-dependent techniques, assessors who have good sensory abilities for the attributes under evaluation are selected and trained in the sensory properties of interest and the protocols involved. More recent methods, however, have been trialled with consumers with some success, but more research is required to understand the value of such data.

Currently, time-dependent methods can be separated into those which track the intensity of attributes over time and those which focus on the order in which attributes occur. In either case, the attributes of interest first need to be identified. When tracking intensity, the focus may be on one attribute; for example, tracking the bitterness profile of beer or the sweetness of a new sweetener over time, or several attributes may be of interest, such as tracking the intensity of different aroma notes in a fabric softener over several days. In such investigations, training assessors to recognise the attributes of interest and to use a scale repeatedly to evaluate their intensity will be a crucial first step. When evaluating the order in which sensations are perceived, again a key process early on is familiarisation of the panel with the perceivable product attributes, although the length of training may depend on the type of assessors. For both categories of techniques, references can be used to help train assessors but if the project is long term then

the effect of time on the sensory properties of the references themselves could become problematic and so would need consideration. When/if using consumers, less time will be focused on this training stage but care needs to be taken in terms of the lexicon of terms employed as to whether it might be too technical. A secondary stage with these types of approach (TDS, TCATA, TOS) is also deciding how many attributes to include in the list. Practice runs and discussions during training can facilitate elimination of attributes that are not likely to be selected during the final evaluation.

In general, time-dependent methods can be more complex and demanding on the assessor than other descriptive techniques. For all methods, training in the protocol is essential. Recording observations while concentrating on perception can be difficult, especially over short time periods. In such cases, considerable practice is required with the recording mechanism which nowadays tends to be a mouse on a scale or a touch screen. If assessing products on or using hands or arms etc. the assessor may need to use a voice recorder to shout out their perceptions according to a timer. For some trials, assessors may need to learn specific protocols to minimise bias; for example, chewing to a metronome, applying cosmetics and creams at a certain rate and so on, all of which takes considerable practice to obtain consistency across products.

Owing to the level of control required in most time-dependent methods, studies on short-term dynamic changes in products tend to take place in a specialist sensory laboratory. Even longer-term studies, for example of the effectiveness of air fresheners, may invite assessors back to the laboratory over several days to evaluate products. Some consultancies, for example, have specially designed labs to enable personal-care products to be tested on the premises. Longer-term evaluations, however, may take place out of the lab, especially if researchers are interested in the response in a more realistic context such as the home. Alternatively, where the product and objective dictate, samples can be prepared in advance to represent different time points (e.g. fabrics stored for different lengths of time, fragrances sprayed on blotter strips at various time points prior to evaluation) enabling different discrete time points to be evaluated in one session.

General rules regarding sample presentation and presentation order apply to time-dependent techniques but, depending on the length of the evaluation, the number that can be assessed in any one session may become problematic. Time-dependent techniques are effective ways of investigating products which have stimuli with a long time course but, often, these stimuli also create carry-over effects which call for the need of very effective palate cleansers or similar, or may mean only assessing one sample per session. The temporal nature of these studies can also mean that adaptation to stimuli is an important consideration.

Indeed, it is not possible to discuss the temporal nature of sensory perception without considering the physiological mechanism known as adaptation. Humans are programmed to respond to changes in the environment so that they can

react quickly if such changes are harmful. Essentially, the nervous system becomes desensitised to any constant stimulus, enabling brain capacity to be reserved for the detection of changes in the environment which are potentially more dangerous. The level of adaptation depends on the modality; for example, adaptation to light is not usually complete, whereas it can be for aroma and touch. For the sensory scientist, this phenomenon can be problematic and, if not controlled, can impact on the validity of data collected from assessors. Controlling adaptation may be more problematic for, or indeed could be considered an inbuilt aspect of, time-dependent methods. Consequently, a whole chapter has been dedicated to this phenomenon in this book. Chapter 4 introduces the concepts and mechanisms behind adaptation in the context of sensory evaluation and provides insights into controlling its effects. Adaptation also features in discussions concerning the theory of sensory memory and, indeed, can also have an important role in the dynamics of liking. Chapters 5 and 6 thus also provide interesting reading for those interested in this phenomenon.

The type of the data generated from time-dependent techniques will depend on the approach that is taken. TI data are by their very nature quantitative and are either collected at discrete time points or continuously. Initially, TI studies employed clocks or audible cues to note the time course of the sensation and assessors rated intensity at specific discrete time points. In the 1970s, Larson-Powers and Pangborn (1978) and Lawless and Skinner (1979) both independently developed strip-chart recorders to register the continuous time course of a sensation. Birch and Munton (1981) then developed the sensory measurement unit for recording flux (SMURF) apparatus, which, instead of using a pen on a moving chart recorder, employed a potentiometer which converted the signal to a strip-chart recorder as assessors turned a dial controlling a variable resistor. In all such approaches, the TI curves were then manually digitised, which was time consuming and laborious. Computers allowed the electronic collection of on-screen data and, not surprisingly, such advances saw an increase in the number of TI studies. Today, computerised systems are available through different software companies for the collection of discrete time–intensity (DTI) and CTI data, which has considerably enhanced the ease and availability of data collection and processing. Such data are then further processed to provide average TI curves across individual assessors or a panel, and several approaches have been suggested in terms of how to best achieve this; for example, Overbosch et al. (1986), Liu and Macfie (1990) and Ledauphin et al. (2006), and are discussed in more detail in Chapter 9. Finally, certain parameters are extracted, such as maximum intensity, time to maximum intensity, area under the curve and time of sensation duration, to characterise the key features of the dynamic sensation. Analysis of variance is then typically applied to these data to identify differences across products for each of the key temporal features.

More recent techniques, such as TDS, TOS and TCATA, focus on evaluating the proportion of observations citing the occurrence of a particular attribute over