CHAPTER 1
Introduction to Descriptive Analysis

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1.1 Introduction

Descriptive analysis is a method used to objectively describe the nature and magnitude of sensory characteristics. It was a pioneering development for its day, and represented a major step forward that gave sensory evaluation a scientific footing through the ability to produce objective, statistically reliable and statistically analysable data. Today, it remains a cornerstone method in sensory analysis.

A wide range of descriptive analysis techniques have been developed since its inception. Traditional descriptive techniques, such as profiling-based methods and quantitative descriptive analysis, involve a panel of trained assessors objectively measuring the quality and strength of the sensory attributes of samples. More recently, faster descriptive techniques, such as sorting, projective mapping and polarized sensory positioning, involve untrained consumers grouping samples based on holistic similarities and differences in sensory characteristics. Over the years, descriptive analysis has proved itself to be flexible and customizable, which has contributed to its usefulness and hence its longevity.

As descriptive analysis enables objective, comprehensive and informative sensory data to be obtained, it acts as a versatile source of product information in industry, government and research settings. Descriptive analysis was first applied to foods and beverages, but is now applied to a broad range of products including home, personal care, cars, environmental odours, plants, etc. It is used throughout the product lifecycle, including market mapping, product development, value optimization, and quality control and assurance. Descriptive analysis is particularly useful in product design, when sensory data are linked to consumer hedonic data and physico-chemical data produced using instrumental measures. This allows product developers and marketing professionals to understand and identify sensory drivers of product liking in order to design products with optimal liking. Sensory descriptive information can also be linked to other types of...
consumer data to enhance brand elements, emotional benefits, functional benefits and marketing communication.

There are many general texts and reviews on descriptive analysis and the reader is directed to the following: ASTM (1992), Gacula (1997), Murray et al. (2001), Meilgaard et al. (2006), Kemp et al. (2009), Lawless and Heymann (2010a,b), Varela and Ares (2012, 2014), Stone et al. (2012) and Delarue et al. (2014).

1.2 Development of Descriptive Analysis

1.2.1 Evolution

Descriptive analysis grew from the need to assess products in a reliable fashion. Originally, product sensory quality relied on assessment by experts, such as brewers, wine tasters, tea tasters and cheese makers, who judged quality on key product attributes and made recommendations on how ingredients and process variables affected production and the finished product, which might often have a very fixed, invariable specification over a long period of time. The expert, sometimes called the ‘golden tongue’, was often a single person, who had product experience or had been trained by other experts. Businesses relied heavily on a few key individuals, which could be problematic if they left, particularly if they were the prime expert on the unique sensory characteristics of a company’s product. Attributes were often important to the manufacturing process, rather than the consumer, and might comprise defects or complex terms that were difficult to understand. Attributes were often assessed using grading on quality scales that might be idiosyncratic to a company, an industry or a country. Indeed, experts could also be idiosyncratic and subjective in their judgements. Data often comprised a single value, which could not be interrogated statistically, making it difficult to compare scores in a meaningful way. In many cases, only the expert could interpret differences in scores between products.

As the market became more complex and fast-paced, with increasing numbers of ingredients, processing technologies, products, competition and consumer choice, the need arose for a more robust system for assessing product quality. The introduction of descriptive analysis moved away from a single expert to a trained panel of assessors, removing the reliance on a single person and making the data more reliable. Controls were introduced, such as experimentally verified scales, physical sensory references rather than descriptive words, consistent assessment methodology and thorough training. As sensory evaluation became recognized as a scientific discipline, good experimental design as used in other scientific areas was introduced, such as elimination of variability and bias, and use of experimental design and replication. This enabled the production of robust, objective data that could be analysed statistically. In a similar fashion, food production had moved from a craft to a science, and data produced
from descriptive analysis now became available for food scientists and technologists to use in conjunction with physico-chemical instrumental measures to understand food quality in a science-based, rigorous manner.

The market continued to grow, and became increasingly international and global. Companies began to manufacture greater volumes, often at many national and international sites, and the rigorous nature of descriptive analysis now made it easier to compare data across studies and across panels, for example, to check that product quality was consistent across manufacturing sites. At this point, descriptive analysis was a key tool for quality assurance and control, and the sensory department was essentially providing a service based on routine testing. Traditional methodologies continued to be honed. In the US, several dominant descriptive analysis methods emerged driven by sensory agencies. In Europe, where the market for sensory agencies was more fragmented, the trend was towards customizing descriptive methodology to suit the needs of individual companies.

With globalization, the marketplace has evolved to be highly competitive. Consumers have become increasingly sophisticated and demanding, with a wide range of choices. To gain a competitive advantage, it is important to deliver consumers’ needs, wants and desires. Product push has given way to consumer pull, and it is now consumers who are the ultimate judges of product nature and quality (Kemp 2013). The applications of descriptive analysis have evolved to become a key tool for use in product design and development, in order to interpret and deliver consumers’ sensory requirements. New product development can be guided to create products based on consumer likes and dislikes. Descriptive data are now routinely combined with consumer data to determine sensory attributes that drive consumer liking, aided by the advances in technology outlined below that have enabled sophisticated, rapid statistical modelling and analysis. Physico-chemical and process data can also be combined in these models to enable manipulation of product characteristics to optimize consumer liking. Sensory attributes of key importance to the consumer can be comprehensively understood, and are now routinely used in quality control and assessment.

As the marketplace has become complex and sophisticated, so has the means of marketing products. There are many ways in which product sensory characteristics play a role in marketing, as described in section 1.4.3, including sensory pleasantness leading to repeat purchase, as an essential brand characteristic, as a functional benefit or indicator of a functional benefit, and as part of the brand/product experience, which is increasingly highlighting emotional aspects. Statistical modelling using descriptive data has been able to illuminate and design sensory characteristics linked to brand elements, functional benefits and emotional benefits. Hence, descriptive analysis is now an important tool for marketing and can be used across the product life cycle. As a result, the sensory department itself has now evolved to become a full partner to marketing and technical functions, rather than a service provider in the quality department.
Descriptive Analysis in Sensory Evaluation

As factors related to the commercial environment have influenced the evolution of descriptive analysis, and indeed sensory evaluation in general, so have advances in technology. Methods of data collection have changed considerably. In the early days, all data had to be collected using pen and paper, and then transcribed into raw data tables by hand. The chance of error was higher and data entry was usually double checked, further slowing progress. Preparing paper questionnaires was time-consuming, and could be complex given the experimental design. Transcribing data from a continuous line scale involved measuring the distance from the end of the scale to the assessment mark with a ruler, which was a daunting task made exponentially larger by the number of attributes, samples, assessors and replicates. The size and complexity of descriptive analysis studies were limited, as was the statistical analysis that was feasible.

The introduction of computers in the 1980s considerably speeded up operations. Initially, computers were expensive and one computer might be used in conjunction with an optical reader to carry out data input and analysis. As computers became faster and cheaper, the process of descriptive analysis became increasingly more automated. Computers were introduced into sensory booths for direct data entry. Bigger studies, more complex experimental designs and faster, more comprehensive data analysis were possible. At the same time, computerized systems were developed to design, manage and run sensory testing, making descriptive analysis easier and more streamlined to perform.

Much more complex and sophisticated data analysis, such as multidimensional scaling (MDS) and generalized Procrustes analysis (GPA), became feasible and routine, leading to the symbiotic development of descriptive methods that relied on this analysis, such as free choice profiling, sorting and other techniques. This also enhanced the application of descriptive data, as complex statistical modelling linking descriptive data to consumer and physico-chemical, instrumental data became possible, using techniques such as preference mapping and response surface methodology (RSM). This enabled the sensory drivers of liking to be identified for consumer-led product development, so that today consumer-driven product design using this approach is the norm for larger companies with the available resources. Sophisticated graphics became possible, making it easier to illustrate results to lay audiences, and hence increase interest and use of descriptive analysis.

The introduction of wireless technology freed computers, so that they became portable, enabling descriptive testing to be carried out on the go in real-life environments. Technology has also become smaller and more robust, so that it can be used easily wherever and whenever necessary. For example, descriptive analysis of shower gels can now be carried out in consumers’ home bathrooms using waterproof tablets in their showers, with data sent for analysis in real time. Mobile phone apps enable data to be collected conveniently as consumers go about their daily lives. The widespread use of the internet and social media has also had an impact, although care needs to be taken to ensure that the identity
and location of the assessor has been verified. Virtual descriptive panels have been set up with group training carried out via web-based sessions, with references and products sent to consumers’ homes. Central location testing still remains convenient, and advances in virtual reality environments have made it more realistic although this is not yet widespread.

In some ways, descriptive analysis has become a victim of its own success. It is now used routinely throughout the new product development cycle, as described above, but this cycle is becoming increasingly faster and shorter. Despite the gains in speed from computerization and other new technologies, traditional descriptive analysis can be perceived as slow to set up, to complete a study and to produce actionable results. Ever faster product launch cycles have lead to the development of more rapid methods for descriptive analysis, such as sorting and flash profiling, in which sensory characteristics for products are compared together rather than individually assessed. Some of these methods can be run with untrained assessors, eliminating what can be several months of set-up time. A study can be completed more rapidly, and although analysis can be complex, speed is on a par with modelling techniques used to link descriptive data with consumer and physico-chemical data. There may, however, be compromise of detail for speed.

Today, descriptive analysis remains a key sensory tool that is highly flexible, with the choice of many standard methods to suit a wide range of applications and the possibility of customization for specific applications. The history of the development of descriptive analysis methods is described in section 1.2.2.

1.2.2 History
1.2.2.1 To 1950s
The early history of descriptive analyses often relied upon ‘golden tongue’ experts, such as brew masters, wine tasters, perfumers, flavourists and others, to guide product development and quality assurance. It was possible for these experts to be reasonably successful when the marketplace was less competitive. From the 1910s to the 1950s, various score cards and sheets were developed by companies and government departments primarily for quality evaluation, and the need for accurate, reliable methods using the appropriate assessors and scales gradually became apparent (see Amerine et al. (1965) and Dehlholm (2012) for a review of early literature, and the latter for an overview of the history of descriptive methods to the present).

With the rapid introduction and proliferation of new products into the marketplace, a need for a formal means of describing food arose. Researchers at the Arthur D. Little laboratory were the first to take the ground-breaking step of developing a robust method called the flavor profile method* (FPM) to meet this need (Cairncross & Sjostrum 1950). They demonstrated that it was possible for

* ‘Flavor profile’ is a formal name in common usage using American English spelling and is therefore cited in this manner.
trained assessors to produce actionable results without depending on individual experts and this was a key change in the philosophy of sensory science. The main features of the method involved analysing a product’s perceived aroma, flavour and aftertaste characteristics, their intensities, order of appearance, aftertaste and overall impression using a panel of 4–6 assessors. However, one weakness of this method was that the data could not be statistically treated.

Several methods based on FPM have been developed. A step in FPM uses consensus profiling, in which a group of assessors work together to produce group intensity scores for attributes, and this is still used as a stand-alone method, although statistical analysis of the data is not possible (see Chapter 6). Other early derivations of the method include the modified diagram method (Cartwright & Kelly 1951) and the dilution flavour profile (Tilgner 1962a,b), although these have not been widely used. A later extension was profile attribute analysis (PAA) (Neilson et al. 1988), developed by Arthur D. Little, Inc., which involved the use of individual assessments of visual, tactile and auditory attributes on category/line scales and incorporated statistical analysis using ANOVA.

1.2.2.2 1960s

As there was a need to apply descriptive methods to food texture assessment, a new method called the texture profile method (TPM) was developed at the General Foods Technical Center by a team of researchers, under the leadership of Dr Alina Szczesniak in the 1960s (Brandt et al. 1963; Szczesniak 1963; Szczesniak et al. 1963). This method involved assessing the quality and intensity of a product’s perceived texture and mouthfeel characteristics categorized into three groups: ‘mechanical’, ‘geometric’ and ‘other’ (alluding mostly to the fat and moisture content of foods). This technique used the ‘order of appearance’ principle from FPM and is conducted in order of first bite to complete mastication by a panel of 6–10 assessors, who must receive the same training in the principles of texture and TPM procedures. The type of scale used in TPM has expanded from a 13-point scale to category, line and magnitude estimation scales (Meilgaard et al. 2006). Similar to FPM, many reference products were not available to researchers outside the UK (Murray et al. 2001). Although data could not be statistically treated, the foundation of rheological principles upon which the method is built are still applicable. However, a few papers have suggested a solution to this by modifying TPM scales (Bourne et al. 1975; Hough et al. 1994). TPM has been applied to many specific product categories, including breakfast cereal, rice, whipped topping, cookies, meat, snack foods and many more (Lawless & Heymann 2010a).

1.2.2.3 1970s

In the mid-1970s, Tragon Corporation developed a method called quantitative descriptive analysis (QDA), later modified and registered under the name Tragon
QDA\textsuperscript{\textregistered} (Stone et al. 1974). This method not only relied on sound sensory procedures but it was also fully amenable to statistical analysis, which was an important advancement for descriptive analysis methodology. Essential features of QDA were the use of screened and trained panels of 8–15 assessors guided by a trained panel leader, effective descriptive terms generated by the panel themselves, unstructured line scales and repeat evaluations and statistical analysis by analysis of variance (ANOVA) (Gacula 1997; Stone et al. 1974). The latter features of QDA not only enabled sensory scientists to obtain descriptions of product differences, but also facilitated assessment of panel performance and variability between products. Nevertheless, one limitation of QDA was the difficulty in comparing results between panels and between laboratories (Murray et al. 2001). In addition, similar to other conventional profiling methods, these techniques required extensive training and were costly to set up and maintain.

The \textit{Spectrum}\textsuperscript{TM} Method was developed in the 1970s by Gail Vance Civille, who presented the method at the Institute of Food Technologists Sensory Evaluation Courses in 1979. This technique was based on FPM and TPM, but unlike these methods, it evaluated all sensory modalities perceived and could be analysed statistically in a similar fashion to QDA data using ANOVA. A key feature was the use of a panel of 12–15 assessors who received in-depth and specialized training on scaling procedures using standard reference lists (Meilgaard et al. 2006). The use of reference products for anchoring attribute intensities purportedly reduced panel variability and gave the scores absolute meaning. This appealed to organizations who wished to use a descriptive technique in routine quality assurance operations (Lawless & Heymann 2010a). However, it also had a few disadvantages, one of which was associated with the difficulties in developing, training and maintaining a panel, as it was often very time-consuming (Lawless & Heymann 2010a). Another limitation of this technique included the difficulty in accessing reference products, as they were often unavailable to researchers outside the US. Substitution of local products could compromise the absolute nature of the scale and make cross-laboratory studies difficult, which may explain why the technique is more widely used in the US than in other countries. The Spectrum Method has been applied successfully to a wide variety of product categories, including meat (Johnsen & Civille 1986), catfish (Johnsen & Kelly 1990), paper and fabrics (Civille & Dus 1990) and skincare (Civille & Dus 1991), to name but a few.

The \textit{ideal profile method} (IPM) came to the fore in the 1970s, with the need to identify the consumers’ ideal product (Hoggan 1975; Moskowitz et al. 1977; Szczeniak et al. 1975) (see Cooper et al. (1989) for a review of early development). Originally, consumers rated predefined product attributes on their perceived and ideal intensities. In later derivations of the method, consumers were also asked to rate product acceptance, such as overall liking and purchase intention. Data analysis is complex, involving several steps to assess consistency, segmentation, definition of the ideal reference and guidance on optimization.
IPM provides actionable guidance for product improvement, although results need to be interpreted with care, particularly as consumer data are variable and consumers showed differences in their ideal profiles (van Trijp et al. 2007; Worch & Punter 2014a,b; Worch et al. 2010, 2012, 2013). Just-about-right scales have also been used to measure consumers’ ideal profiles (Popper 2014). As this method measures consumer hedonics, it is beyond the scope of this book to cover it in detail.

**Difference from control profiling** (also known as deviation from reference profiling) was developed by Larson-Powers and Pangborn (1978a), who found that the deviation from reference scale improved the precision and accuracy of sensory responses. This technique uses a reference sample against which all other samples are evaluated on a range of attributes using a degree of difference scale. For example, samples that scored less than the reference for a specific attribute were indicated by a negative, whereas those that scored more were indicated by a positive (Lawless & Heymann 2010a). Stoer and Lawless (1993) felt this technique would be more effective to distinguish among difficult samples, or when the objective of the study involved comparisons to a meaningful reference. For example, Labuza and Schmidl (1985) used this technique to compare control product with product that had undergone accelerated shelf-life testing and demonstrated that it is useful for quality assurance or quality control work.

The importance of measuring sensory changes in products over time had long been recognized, but was difficult to carry out practically in the early days of sensory science. Continuous **time-intensity (TI) analysis** was presented in its modern form by Larson-Powers and Pangborn (1978b). Unlike conventional descriptive techniques, TI incorporated temporal aspects by continuously recording the evolution of a given sensory characteristic over a period of time. The result of TI measurement was typically a curve showing how the perceived intensity of the sensation increased and then decreased during consumption of a product. The measurement of temporal perceptual changes had been of interest for some time beforehand; an early example is Holway and Hurvich (1937), who asked assessors to trace a curve on paper to represent salt intensity. Other early methods involved making multiple assessments at short time intervals and constructing curves from the data (Sjostrom 1954) or plotting intensities on a paper graph, where the x-axis was time and the y-axis was perceived intensity (Neilson 1957). Larson-Powers and Pangborn were the first to gather continuous TI data, using a moving strip-chart recorder, in such a manner that assessors were required only to move a pen along a line scale to assess intensity and could not see their evolving curves to avoid bias.

As technology progressed, data were collected by computers; the first computerized system was developed by the US Army Nadick Food Laboratories in 1979 (Lawless & Heymann 2010b), which lead to a proliferation in TI studies. Statistical analysis of TI curves proved complex, and required some development. Assessors were often already trained QDA or profiling panellists, who
were then trained in the TI assessment technique. TI was useful to describe a variety of ingredients and products with longer-lasting or changing sensory experiences (e.g. chewing gum, perfume) or products that changed over time through use (e.g. ice cream), and has also been used to understand how perception changes throughout consumption experience (e.g. sipping a cup of hot tea) (Kemp et al. 2009) and to investigate mechanisms of human perception (Piggott 2000). TI has the benefit of providing more detailed information than other descriptive techniques, but is time-consuming as evaluation is limited to one attribute at a time and requires a large number of assessments to cover even a small number of important product attributes. For reviews of TI, see Halpern (1991), Cliff and Heymann (1993), Dijksterhuis and Piggott (2000) and Lawless and Heymann (2010b). Temporal methods are beyond the scope of this book and will be covered elsewhere (Hort et al. 2017).

1.2.2.4 1980s
A more rapid method called free choice profiling (FCP) was developed in the UK during the 1980s (Williams & Langron 1984). This technique also met the demand and interest of marketing and product development teams in obtaining consumers’ perception of products. Unlike other previous descriptive methods, this method allowed consumers to generate and use any number of their own attributes to describe and quantify product attributes. Therefore, as the assessors did not require any training, the process of data generation was relatively quicker and potentially cheaper compared to conventional techniques. However, one distinct challenge of the technique was the use of idiosyncratic words from consumers, such as ‘cool stuff’, ‘mum’s cooking’, which made the interpretation of results difficult (Lawless & Heymann 2010a). Another factor to take into account was the different number of descriptors generated by the consumers; some used very few descriptors while some used many. Therefore, this method needed more sophisticated techniques, such as GPA, to transform each assessor’s data into individual spatial configurations (Gower 1975). This technique has now been successfully applied to a range of products, such as alcoholic beverages (Beal & Mottram 1993; Gains & Thompson 1990), coffee (Williams & Arnold 1985), cheese (Jack et al. 1993), meat (Beilken et al. 1991), salmon (Morzel et al. 1999) and many more (see Tárrega & Taracón (2014) for a review).

Conventional descriptive and time-intensity techniques were not suitable to evaluate products with high individual variability in consumption speed, such as cigarettes. Gordin (1987) therefore developed the intensity variation descriptive method, which took account of individual consumption speed and provided information about changes in attribute intensities as samples were consumed. This technique asked assessors to evaluate products at specified locations in the product rather than at specified time intervals using standard descriptive methodology.

Sorting procedures were introduced as a descriptive technique in sensory science in the late 1980s. Assessors were asked to group samples according to their
similarities and differences. Perceptual maps were created from the data. The inclusion of verbal description in the assessment enabled the dimensions of such maps to be explained (Popper & Heymann 1996). There are many variations on the exact sorting procedure applied or developed in sensory science (Chollet et al. 2014; Courcoux et al. 2014), including restricted sorting (Lawless 1989), free sorting (Lawless et al. 1995), descendant hierarchical sorting (Egoroff 2005), directed sorting (Ballester et al. 2009), ascendant hierarchical/taxonomic free sorting (Qannari et al. 2010), Sorted Napping® (Pagès et al. 2010), labelled sorting (Bécue-Bertaut & Lê 2011) and multiple sorting (Dehlholm et al. 2012, 2014b). Sorting techniques required minimal training, could be applied to a large number of samples and did not require any selection of attributes in advance, making them easier, quicker and cheaper to perform compared to other conventional techniques (Cartier et al. 2006). Lawless (1989) was probably one of the first to use this technique to profile sensory characteristics of odourants. Sorting has been applied on a variety of food products, including beers (Chollet & Valentin 2001), cheese (Lawless et al. 1995) and yoghurts (Saint Eve et al. 2004), and to evaluate different materials, such as plastic pieces (Faye et al. 2004) and fabrics (Giboreau et al. 2001). However, this technique should be limited to foods whose physico-chemical properties (temperature, structure, etc.) and resulting sensory properties remain stable throughout the sensory sessions (Cartier et al. 2006). Therefore, it is not appropriate to apply this technique in shelf-life studies.

1.2.2.5 1990s

Quantitative Flavour Profiling (QFP) was developed by Givaudan-Roure, Switzerland, as a modified version of QDA (Stampanoni 1994). Unlike QDA, this technique assessed flavour characteristics using a predefined lexicon for different product categories developed by a panel of 6–8 panellists, who were usually trained flavourists. Intensity was assessed by a trained panel using a line scale and end-of-scale intensity references were used for each study. A proposed advantage of QFP was its use of technical and non-erroneous terms from the experts (Murray et al. 2001). However, it also posed a challenge for marketing and product development teams to link the data to consumer perceptions and preferences. Nevertheless, the use of reference standards made this technique applicable for cross-laboratory and cross-cultural projects (Murray et al. 2001). QFP has been applied to profile foods, such as dairy products (Stampanoni 1994).

Projective mapping (Risvik et al. 1994) was proposed as a rapid method for sensorically mapping products. Untrained assessors were presented with all samples simultaneously and asked to physically place samples in space (on a sheet of paper or, more recently, by placing icons on a computer screen) so that perceptually similar samples are close to each other, and those that are more different are placed further apart, thus producing a physical representation of a
perceptual map. GPA was applied for data analysis. *Napping*® is a variation on projective mapping (Pagès 2003, 2005a,b), which uses the same assessment procedure but has a more defined set of data analysis instructions. Several variations exist, including Napping with the addition of ultra-flash profiling, in which assessors also provide semantic description of products (Pagès 2003), Sorted Napping, in which assessors provide descriptions of product groupings (Pagès et al. 2010), Partial Napping, where assessors are guided, for example by sensory modalities (Dehlholm et al. 2012), and Consensus Napping, in which assessors give group assessment, although the latter was found to be unreliable with untrained assessors (Delholm 2014a). A major advantage of projective mapping was its spontaneity, flexibility and speed (Perrin et al. 2008). However, this technique did not characterize the product in detail and product description often had to be completed with sensory or instrumental data. Many variations of projective mapping exist which can influence results, including response surface framework, assessor instructions, assessor type and validation of product separations (Dehlholm et al. 2012) (see Dehlholm (2014a) and Lê et al. (2014) for a review).

*Progressive profiling* (Jack et al. 1994), which is similar to the intensity variation descriptive method discussed previously (Gordin 1987), merged the dynamic ideas from time intensity with ideas from flavour and texture profiling. This technique asked assessors to give an intensity score to an attribute at several time points, such as at each chew, chosen by the experimenter during the evaluation, and used references to allow comparison over time. However, limited correlations were found between progressive profiling, descriptive analysis and instrumental measurement when profiling textural attributes of hard cheese during mastication (Jack et al. 1994).

The *dynamic flavour profile method* (DeRovira 1996) was another extension of descriptive analysis and time-intensity methodology. The panels were trained to evaluate the perceived intensities of 14 specific aroma and taste attributes over time, including acid, bitter, brown, esters, floral, green, lactonic, salt, sour, spicy, sulfury, sweet, terpenoid and woody. The data produced a set of TI curves that characterized a sensory profile and were represented in three dimensions, whereby a cross-section of the plot yields a spider plot for a particular time point. Although the specification of 14 attributes was argued to be too restrictive, the method was deemed to have potential (Lawless & Heyman 2010a,b).

*Dual-attribute TI* (DATI) (Duizer et al. 1996) was developed to enable two sensory attributes to be measured simultaneously using continuous TI, thus halving the time required for single-attribute sensory evaluations. Although DATI was claimed to produce meaningful results (Zimoch & Findlay 2006), it has not been widely used, as assessors often found it difficult to assess and record two sensory characteristics at the same time, and therefore this technique requires further demonstration of its validity and value before it is widely accepted (Dijksterhuis & Piggot 2000).
1.2.2.6 2000s to the Present

This recent period of time has seen renewed interest in descriptive analysis, with a plethora of studies on new, rapid techniques with many modifications and variations. Sieffermann (2002) proposed a new technique called flash profiling. Untrained assessors selected their own attributes to describe and evaluate a set of products simultaneously, and then ranked the products using their own constructs. It was based on FCP but unlike FCP, which involves rating intensities, flash profiling required assessors to rank products on an ordinal scale for each attribute, and was therefore quicker than FCP. The individual maps created were then treated with GPA to create a consensus configuration. Cluster analysis could then also be performed on the descriptive terms to aid interpretation (Dairou & Sieffermann 2002; Tarea et al. 2007). The main advantages of this technique were that it was less time-consuming and more user friendly to run than conventional descriptive analysis (Sieffermann 2002), although data analysis was more complex. Flash profiling has been proven to be comparable to conventional profiling when assessing a set of red fruit jams, but this could be due to the large differences between the products evaluated (Dairou & Sieffermann 2002). Sieffermann (2002) proposed that flash profiling should be considered as a preliminary test rather than a substitute for conventional profiling. Nevertheless, this technique has shown practical feasibility in the evaluation of a variety of food products (Petit & Vanzeveren 2014), including dairy products (Delarue & Sieffermann 2004), apple and pear purées (Tarea et al. 2007), bread odourant extracts (Poinot et al. 2007), jellies (Blancher et al. 2007), etc. (see Delarue (2014a,b) for a review). Individual vocabulary profiling (Lorho 2005, 2010), a variant of flash profiling, gives better defined individual vocabularies and has been applied to sound quality evaluations.

Rank descriptive data (RDA) (Richter et al. 2010) is a variation on flash profiling, and was based upon an earlier method using ranking with an untrained panel (Rodrigue et al. 2000). In RDA, assessors developed an attribute list, were familiarized with ranking and developed a consensus rank ordering. It was found to give similar discrimination to QDA, whilst being quicker and using a smaller amount of product.

Another related technique, polarized sensory positioning (PSP), is a reference-based method for sensory characterization based on the comparison of samples with a set of fixed references, or poles (Teillet 2014a,b; Teillet et al. 2010; Varela & Ares 2012). There are several modifications, including PSP based on degree of difference scales and triadic PSP (Teillet et al. 2010), where an assessment is made about which reference product the test product is most and least similar to. Although the method is cheap and flexible, the comparison of samples and poles is again based on overall differences, without full product description, an indication of the sensory attributes that should be considered in the further evaluation or their relative importance.
Polarized projective mapping (PPM) (Ares et al. 2013) is a combination of PSP with projective mapping that enables the evaluation of samples in different sessions. Assessors are presented with three poles located on a piece of paper and asked to position sample products in relation to the poles so that perceptually similar samples are located close to each other and perceptually dissimilar samples are further away. Assessors can then be asked for product descriptions. Analysis is similar to that for projective mapping.

Another method that uses a reference is Pivot Profile© suggested by Thuillier in 2007 (see Valentin et al. 2012), in which free descriptions of the differences between a sample product and a single reference product (the ‘pivot’) are produced by asking assessors to list the attributes the product has in smaller or greater intensity than the pivot.

Temporal dominance of sensations (TDS) (Pineau & Schlich 2014; Pineau et al. 2003, 2009) was developed to evaluate product attributes simultaneously over time. TDS primarily records the sequence of the dominance of different attributes; however, it could also be used to record the intensities of each of the dominant sensations. The technique consists of presenting a panel of trained assessors with a complete list of attributes on a computer screen and asking them to identify, and sometimes rate, sensations perceived as dominant until perception ends. TDS has been shown to provide information on the dynamics of perception after product consumption that is not available using conventional sensory profiling (Labbe et al. 2009). However, Ng et al. (2012) have shown how using QDA and TDS in tandem can be more beneficial than using each alone. Temporal order of sensations (TOS) (Pecore et al. 2011) is a faster variation of TDS, which measures the order in which key attributes appear over the consumption experience.

Sequential profiling (Methven et al. 2010) is a modified version of progressive profiling, in which up to five attributes are scored over consecutive tastings, at set time intervals, in order to determine the perception of sensory attributes upon repeat consumption of a product over time. It has been shown that this technique generates additional information over standard techniques, such as a significant build-up of some attributes (e.g. mouthcoating) over total consumption volume. Several other methods that also make measurements at set time intervals include time-related profiling (Kostyra et al. 2008), time-scanning descriptive analysis (Seo et al. 2009) and multi-attribute time intensity (MATI) (Kuesten at al. 2013).

Conventional methods continued to be developed with the aim of reducing the time for evaluation. In 2010, HITS profiling (high identity traits) was proposed as a quicker method that provided more user-friendly information than traditional descriptive analysis techniques (Talavera-bianchi et al. 2010). The method used a simplified lexicon with fewer and more user-friendly attributes that could be understood by different users of the data. In 2012, the optimized descriptive profile (ODP) method was published (da Silva et al. 2012) with the aim
of reducing the time for evaluation while estimating the magnitude of differences between samples. Assessors were familiarized rather than trained on references, and assessment was carried out on each attribute for all products, rather than for each product on all attributes. ODP was found to be 50% quicker than conventional profiling, whilst giving a similar sensory profile and discrimination power (da Silva et al. 2013).

Recently, verbally based qualitative methods have received attention in sensory science. ‘All-that-apply’ methods, most often called ‘check-all-that-apply’ (CATA) or ‘tick-all-that-apply’ (TATA), involve assessors selecting all terms that apply to a product from a list of words. A variation is ‘Pick-K attributes’ (or Pick K over N), in which assessors select the K terms that are dominant or best describe the product. The CATA technique originated in the 1960s (Coombe 1964) and has been used in marketing research with consumers for decades, with ballots typically including CATA questions along with hedonic questions. In the experience of the authors, CATA lists for marketing research studies on food, beverage and fragranced products often included ‘simple’ sensory terms, such as ‘sweet’, ‘citrus’, ‘strong’, ‘weak’, etc., that were used for top-line product guidance. For example, at least since the 1990s, fragrance companies have used CATA to obtain sensory profiles of blinded fragrances and fragranced products using an attribute list of pure sensory terms (e.g. citrus, floral, strong), mixed with consumer terms (e.g. sporty, sophisticated). Interest in the application of CATA for more detailed sensory description was sparked in 2007 (Adams et al. 2007) and since then several variations have been proposed, including Pick K, or Pick K from N, in which assessors choose a set number of attributes (K) from the overall list (N) that best describe the product (see Valentin et al. (2012) for an overview), forced-choice CATA/applicability testing, in which assessors are required to answer yes/no questions to every attribute in the list (Ennis & Ennis 2013; Jaeger et al. 2014) and rate-all-that-apply (RATA) (Ares et al. 2014), in which assessors rate the terms they ticked as ‘apply’ (see Meyners & Castura (2014) and Ares & Jaeger (2014) for reviews).

An extension of CATA is temporal check-all-that-apply (TCATA) (Castura et al. 2016) which allowed continuous selection and deselection of multiple applicable attributes simultaneously over time. It built upon TDS, and used an approach similar to time-quality tracking (Zwillinger & Halpern 1991), an earlier method that also captured a sequence of attribute qualities without intensity scaling. Trained assessors indicate and continually update attributes that apply, thereby tracking sensations in the product as it changes over time. TCATA fading is a further development of TCATA, in which selected terms gradually and automatically become unselected over a predefined period of time (Ares et al. 2016). Results indicate that the TCATA and fading TCATA techniques have potential, but further research is needed to refine the methodology.

Open-ended questioning is another verbally based qualitative method that has recently received attention in sensory science. Assessors are asked for an opinion
or comment and allowed to answer spontaneously and freely. Analysis of data may be carried out using a variety of techniques, including chi-square, chi-square per cell, correspondence analysis and multifactor analysis. Free comments are collected as supplementary information to other methods, such as sorting and Napping techniques. Open-ended questioning with subsequent comment analysis has been used to obtain product descriptions in consumer vocabulary (Ares et al. 2010) (see Symoneaux & Galmarini (2014) and Piqueras-Fiszman (2014) for reviews of methodology and analysis).

1.2.2.7 Continuing Customized Modification

The development of descriptive analysis illustrated above from the early days of 1950s to the present has given rise to many techniques, all of which have their relative merits. Since the earliest times of descriptive analysis, companies have developed their own customized methodology to meet specific project objectives or as their standard in-house methodology, which enables the most appropriate elements of different techniques to be modified and utilized. Most in-house descriptive methods are proprietary, but two examples of methods based on customization available in the public domain are QFP (see above and Chapter 10) and the *A5adaptive Profile Method®* (see Chapter 11).

1.3 Descriptive Analysis as a Technique in Sensory Evaluation

1.3.1 Descriptive Analysis as a Tool

Descriptive analysis provides detailed, precise, reliable and objective sensory information about products. It uses humans as measuring instruments under controlled conditions to minimize bias in order to generate such data. In traditional methods, such as profiling-based methods and QDA, assessors with good sensory abilities are selected and trained for up to 6 months to rate perceived intensity and quality in a manner that is consistent within themselves and with other assessors to produce data that have been validated as acceptable (Heymann et al. 2014). Newer methods, such as FCP, flash profiling, sorting, projective mapping and PSP, can use naive consumers with no prior experience or training to group products based on overall similarities or differences, sometimes identifying and naming product differences first and then measuring them, or grouping products and then naming groups afterwards (Varela & Ares 2014).

There are some generic steps that are common across most traditional descriptive methods: assessor screening and selection; assessor training, including attribute generation, intensity calibration, development of assessment protocol and performance check; data generation using replication; and data analysis and reporting (Kemp et al. 2009). Newer, ‘rapid’ techniques have fewer generic steps: data generation, and data analysis and reporting (Dehlholm 2012). Some
also include a prior familiarization step. Testing is quicker as there are fewer initial steps, so that a study can be completed in as little as one day, which reduces costs, although data analysis is more complex. However, it is noteworthy that once the panel in traditional techniques has been trained, subsequent studies on the same product/product category can also be run in a similar time-scale to newer methods, depending on the number of samples, without the inconvenience of having to recruit assessors for each study.

A key factor in the choice of descriptive analysis method is the choice of assessor, who may have no training, some familiarization or intensive training. Generally, the lower the level of training, the higher the variability of data produced and so the higher the number of assessors needed. Traditional methods use highly trained assessors, with the Spectrum Method said to use the most intensive training. Product experts have also been used, who may be more or less experienced than a trained panel. Newer techniques can use consumers with no training, but the trade-off is more variable data that are more difficult to interpret. Consumers may have differing levels of experience and expertise, ranging from naïve consumers with no prior experience to category, product or brand users. Highly brand-loyal users can be more discriminating than trained panels. Newer methods give different levels of familiarization. For example, in FCP, assessors are exposed to many test samples when eliciting differences prior to the measurement phase, whereas some free sorting techniques provide no familiarization with the technique or samples.

Many studies have compared methodologies (a comparison of methods is given in Chapter 20) (see Ares & Varela (2014), Stone (2014) and Valentin et al. (2012). Often, similar results were obtained, although data from rapid methods appears less reliable and consistent (Dehlholm 2012). The most important factor when choosing a method, as for any good scientific study, is that the method selected should be appropriate to the objective of the study, and be able to produce actionable results and recommendations. Whichever method is used, good experimental controls, careful attention to practical experimentation and robust data analysis as described below will give confidence in the results obtained.

Descriptive analysis studies are typically carried out in a sensory laboratory with a controlled environment, which is neutral and has controlled lighting, temperature and humidity (ASTM 1986). Samples are produced/obtained, presented and assessed in such a way as to eliminate irrelevant and unnecessary variability and bias. Samples may be prepared according to experimental designs, depending on the objective, for example to vary ingredients and physico-chemical properties in a systematic manner. Experimental designs for sample presentation are employed to eliminate bias, which may range from a simple balanced, complete block design to a complex nested, incomplete block design, depending upon the number of samples and experimental variables. Traditionally, samples are presented in a sequential monadic fashion and all
Attributes are assessed for each product. Descriptive testing has also been carried out on an attribute-by-attribute basis, often using ranking or rank-rating (Kim & O’Mahony 1998) (later termed positional relative rating by Cordinnier and Delwiche (2008)), in which all products are assessed on each attribute in turn. In comparisons between serial monadic and attribute-by-attribute protocols with untrained assessors (Ishii et al. 2007) and trained assessors (Ishii et al. 2008), untrained assessors performed better using attribute-by-attribute evaluation, while the reverse was true for trained assessors. For newer methods, samples presentation may be simultaneous.

Data generated can be purely qualitative although, most often, they are quantitative and can be generated using a variety of measurement techniques, such as ranking, category scales, line scales and magnitude estimation, all of which have advantages and disadvantages. Replication of typically between two and four replicates is used to provide reliability, that is, to demonstrate that the data are reproducible under the same experimental conditions. Data are compared using statistical analysis, such as ANOVA, to determine significant differences in sensory characteristics between samples. Multidimensional statistics are used to produce descriptive maps of sample sets, and are the most appropriate method of analysis for some methods, such as FCP and sorting. Typically, data from traditional methods can be combined across studies with the use of suitable experimental elements, such as common controls, references and samples, and across an extended period for data mining, whereas this is more difficult for some of the newer methods, such as rank rating, sorting and projective mapping.

Descriptive analysis is used to give a precise description of the sensory properties of products and comprehensively describe the nature of the differences between them. It may be used to assess sensory characteristics from all sensory modalities and traditional methodology can be used to provide a full sensory description. Some methods, such as flavor and texture profiling, focus on restricted modalities. It is also possible to focus only on selected modalities and sensory attributes, such as those that are important to consumers. Traditional methods measure attributes individually, whereas newer methods, such as sorting, projective mapping and PSP, compare many attributes simultaneously to assess overall sensory similarities and differences holistically, that is, without the need to be trained to identify individual attributes.

Conventional profiling-type panels are intensively trained on and work with a technically based, well-defined attribute list. QDA panels are trained on and work with less technical language. The language tends to become more predefined for studies subsequent to the initial study in which attributes are generated. FCP assessors are able to choose individual attributes without training that are in effect consumer terms, such as creamy, refreshing. Other rapid techniques may allow for description of products or product groups before or after measurement. Technical terms (e.g. vanillin) are more informative to
product development as they can be related directly to ingredients and process variables, but may need to be linked to consumer data for directional guidance. Consumer terms reflect the language of the target population better than technical terms from the experts and more traditional techniques, and are of more interest to marketing teams, but may be difficult to interpret and action for product development.

The sensory characteristics of products change over time. The time period may be as short as a single bite, for example the change of a frozen dessert in the mouth from a hard, cold solid to a warm, liquid releasing increased flavour volatiles, to a much longer time period, of perhaps many weeks, for example an air freshener gel gradually releasing less fragrance. These changes in perceived product sensory characteristics over time are partly due to changes in consumers’ sensory systems that these products induce, such as short- and long-term adaptation, as well as changes in the products themselves. Descriptive analysis can be used to measure sensory changes in time, either by simply applying typical descriptive methods at specific time points or by using specially adapted descriptive methodology. It is beyond the scope of this book to cover such time-intensity methodology, which is given comprehensive coverage in another book in this series (Hort et al. 2017).

Descriptive analysis techniques are flexible and most methods have been adapted to suit the needs of particular industries, products, projects or applications. As discussed at the end of section 1.2.2, many companies develop proprietary, in-house, customized methodology. These can take elements from other descriptive methods, and often include generic steps that are common across several descriptive techniques, which allow the most suitable philosophies of various methods to be modified, combined and used. Different descriptive techniques may be used in combination to provide more comprehensive information or to improve efficiency. For example, a rapid method may be used to obtain an initial ‘look see’ before employing a longer, more in-depth and more expensive technique.

A major benefit of descriptive analysis is its ability to give additional, comprehensive information above other sensory methods and it is often used in conjunction with them. Discrimination testing is more sensitive than descriptive analysis at detecting differences and, as it is typically quicker and cheaper, it is often used as a first step to determine whether there are significant sensory differences between products. If it is unclear whether a sensory difference exists between products, it is sensible to carry out discrimination testing first to confirm this before committing additional resources to descriptive analysis. Discrimination testing cannot, however, give the level of information about the nature of sensory differences that descriptive analysis can.

Without objective, detailed descriptive data provided by descriptive analysis, understanding consumers’ sensory needs would be much more difficult. Consumers are good at articulating their sensory likes and dislikes, but are not
good at telling us why. Consumer product testing provides information on sensory hedonics and preference, but it is difficult to interpret in an actionable manner. Data from descriptive analysis can be linked to consumer liking and preference data using techniques such as preference mapping, in order to identify sensory drivers of liking and groups of consumers with similar sensory preferences.

Descriptive analysis produces data that are objective, precise and repeatable. In other words, it produces data that are on a par with data produced from analytical instruments, but with greater variance due to inherent variation within and across individuals. This enables sensory data to be robustly linked with instrumental data, such as physico-chemical data, leading to better understanding of the perception of products. The human senses remain more sensitive than instruments, such as the electronic nose, and these methods must be calibrated against the human senses, often using descriptive analysis, before they can be used as stand-alone methods.

Data from descriptive analysis are at their most powerful when used with consumer and instrumental data for product design. This enables the key attributes for consumer liking and disliking to be identified and manipulated to give optimum benefits.

Data from descriptive analysis has become more important in marketing to understand how consumer factors, such as language, perceptions, liking, expectation, emotion, values and behaviour, are related to a product’s sensory properties for use in branding, communication and advertising. Further details are given in section 1.4.3.

1.3.2 Advantage and Disadvantages

The main advantage of descriptive analysis is the type of information it can provide: a comprehensive sensory description of a product that enables the comparison of multiple sensory characteristics within and across products. It can be, however, more time-consuming and expensive than other sensory methods. Traditional descriptive methodology takes more time to design, set up and carry out. In general, compared with other sensory methods, data analysis is more complex, particularly when linking descriptive data to other data and displaying results. Although newer descriptive techniques are faster and cheaper than traditional methods, as they can be completed with little or no training and hence less lead time for data generation, the trade-off is that data analysis is longer and more complex, and the information gained less detailed.

The use of a panel of trained assessors has advantages and disadvantages. The human sensory system is more sensitive than any instrument and so more subtle and complex sensory nuances can be picked up. A disadvantage is that humans are not as consistent as instruments in that they are subject to individual variation and bias. Assessors are all individuals who perceive things differently, for example due to physiological differences; process sensory information differently, for
example using words and scales differently; and have different abilities to carry out the work, such as focus, maintaining motivation, personality, etc. Some argue that humans may have limited capacity to distinguish components of mixtures and question whether the theory of psychophysical modelling upon which traditional descriptive analysis is based is meaningful for complex attribute description (Laing 1991). Rapid methods make holistic measurements, and are therefore said to be closer to ‘true’ perception. However, they are more idiosyncratic and so less reliable than traditional methods.

Bias can be overcome with the use of training, references and controlled experimental conditions, such as procedure, design and environment, although this increases time and costs. However, once a trained panel is set up, in general, it can operate efficiently and continuously with few breaks as a workhorse for data generation, although it requires some maintenance. There is a risk that previous experience can influence current studies. For example, once attribute labels, references, scale types or scale ranges have been learned and used in a particular way, it can be very difficult for panellists to change usage. This is also true of the conceptual structure derived from sorting (Ishii et al. 1997). Some newer methods do not use trained panels, which can reduce risk associated with prior knowledge, as well as time and costs, although this may introduce other disadvantages, such as the need to recruit assessors for each study and the ability to compare across sessions and sample sets.

Descriptive studies can use large varieties and quantities of samples that need to be ready for testing simultaneously. In-house sample production can be time-consuming and expensive, taking up resources and potentially pressuring the department producing the samples. If produced via the production line, it may be difficult to balance requirements with those of immediate commercial needs. If samples need to be purchased, such as competitive products, this can be more expensive, and also resource intensive in order to ensure products are from the same batch, age, etc. Storage can be problematic, as all samples must be stored under stable, similar conditions (unless investigating effect of storage conditions). Control and reference samples must typically be available consistently, and be stored stably, over a longer period.

Descriptive analysis is typically carried out in a laboratory under controlled conditions and this may not represent what occurs under real-life conditions. However, as discussed in section 1.2.1, descriptive analysis is increasingly being carried out in more realistic contexts, aided by new technology.

The success of descriptive analysis boils down to stringent panel screening and training (where appropriate), and proper sensory execution and management, which are rarely inexpensive and easy. It requires a long-term commitment from the company or research centre. However, the benefits of having this important and sensitive analytical descriptive analysis usually outweigh the disadvantages. For this reason, descriptive analysis continues to be an important tool.
1.4 Application of Descriptive Analysis

The evolution of descriptive analysis techniques described in the previous section has been driven by the desire to broaden the scope of its application from a stand-alone method for comparing the sensory properties of products, which was most useful for QA/QC, to a key element in sophisticated consumer-driven product design and marketing. It is now used across many industries, including food, beverages, personal care, household, cosmetics, fragrances, pharmaceuticals, automotive and many others.

1.4.1 Product Development and Design

Descriptive analysis is used throughout the product design and development process to provide information about product differences, sensory drivers of liking and competitor analysis as a function of ingredient, packaging and process variables.

1.4.1.1 Market Overview and Opportunity Definition

One of the prime uses of descriptive analysis in product development is to compare the perceived sensory characteristics of products on the market. This might be to compare current products and their competitors for benchmarking and monitoring, to carry out a category or market review or to look for opportunities, such as sensory characteristics and combinations that are not delivered by the market or the current product range. Originally, this was carried out using pure sensory description, but linking sensory to consumer data, such as hedonics, enables sensory-based consumer segments to be identified and targeted.

1.4.1.2 New Product Design and Development

Once opportunities have been identified, a precise sensory target can be defined using descriptive analysis. The product development process can become more time- and cost-effective when prototypes matching the target have been developed using descriptive analyses coupled with experimental design and modelling to link physico-chemical properties, obtained via instrumental measures, to sensory and consumer data, rather than using trial and error. Such models can help product developers focus on attributes that are important to consumer segments, rather than just noticeably different, at different stages of consumer/product interaction, such as before, during and after product use. In addition, descriptive analysis helps to guide product developers to develop innovative products, through pilot plant scale-up, production benchmarking, package design, storage trials, cost reduction, product/processing change and product optimization.
1.4.1.3 **Product Optimization**

Product optimization may be carried out, for example, to improve liking, reduce costs, create value or substitute ingredients. Descriptive analysis can be used for all of these applications, using modelling techniques linking sensory, instrumental and consumer data as described above. However, descriptive analysis may not be the most appropriate technique when the objective is to match the current product or the sensory differences are expected to be very small. In these cases, discrimination techniques may be more appropriate.

1.4.1.4 **Protection of Competitive Advantage**

Once a product, ingredient or process has been developed, the competitive advantage gained needs to be protected. Sensory properties and/or the means by which they are produced form part of the competitive advantage and descriptive analysis plays a role in their protection.

Data from descriptive analysis have been used to support patents. It is recommended that a study for the sole purpose of defending the patent is carried out. A disadvantage is that the full experimental protocol must be disclosed in a patent, which could mean putting proprietary descriptive methodology in the public domain. The protocol used to support the patent needs to be chosen with care and could be a modification of proprietary descriptive methodology to prevent full disclosure or a non-proprietary descriptive method already in the public domain.

Some signature sensory characteristics, such as a precise colour, flavour or fragrance, that form part of a branding mix, or a perception that is an integral part of the product, such as the smell of a fine fragrance, can be protected by copyright or trademark. In this case, a precise specification of the sensory characteristic is needed, which is often obtained using descriptive analysis. Such data have also been used in court to support cases brought for breach of copyright.

1.4.2 **Quality Assurance and Quality Control (QA/QC)**

Initially, descriptive analysis had its roots in ‘golden tongue’ experts used to assess product quality. Trained panels were introduced to move away from the idiosyncracies of individual experts and produce structured, comparable and validated data that could provide documentation and comparison of perceived sensory characteristics of the current products for quality control and assurance. Formal quality control sensory programmes using trained panels were initiated in the 1950s; however, awareness of their importance arose in the early 1960s, resulting in the establishment of QC sensory programmes in industry. There was increased publication of quality control sensory techniques in the 1990s, including two important texts (ASTM 1992; Munoz et al. 1992). QA/QC has become increasingly consumer driven, in line with technique development as described above, determining and focusing on the sensory
attributes that are important to consumers, and ensuring that production remains within ranges giving the optimal perceived intensity of such sensory characteristics.

Trained descriptive QA/QC panels are used to:

- assess the sensory quality and consistency of ingredients
- assess consistency of production runs and batches
- assess consistency of products from different manufacturing sites
- detect sensory defects before products go to market
- describe how sensory characteristics of the product change over time for shelf-life testing
- assess the quality and consistency of the product through the supply chain
- investigate consumer complaints
- investigate taints.

The most important criteria of a QA/QC sensory programme are the training of assessors, the type of established sensory specification and the use of controlled test conditions (Munoz 2002). Kilcast (2010) gives a practical guide to using descriptive analysis for QA/QC. It typically involves a shortened version of the full sensory descriptive profile, focusing on key sensory attributes of importance to the consumer or the manufacturing process. It may be more convenient to use instrumental rather than sensory measures for routine QA/QC, in which case instrumental measurements must be validated against sensory measures through sensory-instrumental data relationship studies to be useful and reliable (Munoz 2002).

1.4.3 Marketing

Sensory and consumer research now routinely focuses on the relationship between sensory properties and overall liking. Modelling, such as preference mapping, enables marketing teams to identify and target consumer segments or regional markets differentiated by sensory preferences. However, in these days of very mature and competitive markets, potential interactions of sensory properties and other factors have become interesting and important. The role of descriptive analysis in market research and consumer science has evolved from hedonic measures to more explicit behavioural measures, such as purchase intentions, and to implicit behavioural measures such as emotional benefits (e.g. chocolate makes me happy and will calm me), expectation, functional attributes (e.g. healthy but less flavourful food is good for me). There is a need to understand how intrinsic factors (food stimulus dependent) and extrinsic product characteristics such as environment, advertising, packaging or production variables influence consumer perception, expectation, emotion, values (Thomson et al. 2010) and hence hedonic responses. The need to understand such complex relationships between product characteristics and consumer behaviour has led sensory scientists to adopt methods from other scientific disciplines, such as the repertory grid method (Gonzáles-Tomás & Costell 2006; Piggott & Watson 1992),
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Mean-end chain (Brunsø & Grunert 2007; Costa et al. 2007) and conjoint analysis (Enneking et al. 2007).

The applications of sensory descriptive data in marketing and advertising include:
- defining and describing the ‘sensory journey’ of product usage
- identifying/optimizing the sensory characteristics of a brand
- understanding the perceptual basis of consumer sensory language for use in communication
- understanding the longer-term sensory-based relationship between the user and the product/brand
- understanding, creating and optimizing sensory cues for functional and emotional benefits
- making and substantiating sensory-based advertising claims.

1.4.4 Research

Descriptive analysis has been applied in basic research in order to understand the human sensory system, and to investigate the basis of physical and chemical stimulation of this system. It has been used in areas such as mechanisms of sensory receptors, individual differences in physiology, molecular basis of sensory functionality, flavour perception mechanisms, sensory processing in the brain, etc.

Model systems and instruments, such as the electronic nose, electronic tongue, Instron®, etc., that mimic and predict the human sensory system have not only enhanced understanding of mechanisms of sensory perception, but eventually could be a cost- and time-effective replacement for a trained descriptive panel. However, our sensory systems are complex, and research has made steady yet slow progress to date (Ross 2009). Combinations of descriptive analysis and instrumental techniques, including those providing data on chemical properties, physical properties and brain functionality, have enabled multimodal flavour perception and the perceptual interactions between the senses to be studied (Eldeghaidy et al. 2011; Hort et al. 2008).

1.5 Contributions of Descriptive Analysis

1.5.1 Contribution to Industry

Descriptive analysis has made a major contribution to industry, partly by virtue of the type of robust sensory data it generates, as outlined earlier. As a consequence, innovation and new product development (NPD) have become more precise, structured and consumer focused, creating better products that better meet consumer needs, taking into account product, pack and process variables.
The manufacturing process is delivering improved sensory quality that is more focused on consumer sensory needs. Prior to descriptive analysis, the QA process relied on individual experts with all their idiosyncrasies. Descriptive analysis has enabled consumer-relevant sensory elements of product specifications to be identified, precisely defined and measured in a way that is stable over time. Product defects can be precisely characterized.

Marketing can better analyse the sensory-based categorization of products, competitors and consumers in the market and target them. Positioning, such as branding, advertising and advertising claims, can be better linked to the product's sensory characteristics to reinforce positioning, and enable sensory elements to become integrated into the positioning.

As the needs of industry have become more demanding, descriptive analysis has evolved to meet the challenges. Descriptive analysis has contributed in many product categories, such as food, beverages, personal care, household, cosmetics, pharmaceuticals, textiles, etc., and the list continues to grow. It has proved adaptable over the years, and a selection of methods is now available for different situations, such as those requiring sensory data that are more detailed, quick to generate, cheap, technically orientated, consumer orientated, stable over time, real to life, etc.

1.5.2 Contribution to Other Scientific Disciplines

1.5.2.1 Psychology

Descriptive analysis involves using humans as an analytical ‘instrument’. Unlike instruments, however, human judgements can be easily affected by psychological factors, and sensory scientists must ensure that the chosen procedure, scale and experimental design minimize psychological biases. The development of descriptive analysis methods has therefore lead to a greater understanding of sensory psychology.

In the early days of traditional descriptive analysis, there was much debate over which type of scale produced the ‘best’ data. Much research was put into understanding how different scales worked perceptually, (e.g. category versus continuous scaling, scale-end bias, etc.), how individuals used scales differently (e.g. conservative scaling, effect of experience, differences in perceptual sensitivity) and how to train individuals to use scales in the same way (e.g. references, controls, blind samples, etc.). Scales were developed and applied to descriptive analysis to attempt to overcome different biases (e.g. the Labelled Intensity Magnitude Scale (LIMS) is used to overcome scale-end bias). Today, it is recognized that there is no one ‘best’ scale, but the most appropriate scale for the particular application (see Lawless & Heymann (2010c) and Lawless (2013) for an overview of scaling).

In a similar way, much research has been carried out on understanding how individuals perceive and use descriptive attributes. Attributes are perceptual
concepts, consisting of a qualitative perceptual experience named with a descriptive word (descriptor). Research has been undertaken on perceptual categorization to understand how individuals designate a perceptual sensation to one attribute or another and learn a system of perceptual categorization. Research has also been undertaken on concept alignment to understand how to train individuals to have the same understanding of an attribute (e.g. use of perceptual references), and on the application of language to perceptual concepts to understand how descriptors are applied to sensory concepts.

In order to perform descriptive analysis, panellists must learn to recognize a range of sensory attributes and remember perceptual intensities. They must use their memory and be motivated to maintain performance, and research has been undertaken on sensory learning and memory in order to devise better training techniques.

The research referred to above has contributed to other disciplines, such as psychophysics and market research.

1.5.2.2 Physiology
As descriptive analysis involves using humans as an analytical ‘instrument’, it is desirable that all panellists produce data in the same way. Panellists, however, are all individuals with differing perceptual sensitivities that can lead to differing use of attributes and scales. Much research has gone into understanding the factors affecting individual sensitivity, including age, health, lifestyle, such as smoking status, genetics, etc., which has been applied to develop a selection process to identify the most sensitive potential panellists. Some selection tests have been used in other disciplines; for example, in-mouth texture related tests have been used in oral-related sciences (Fillion & Kilcast 2001) and odour recognition tests have been used in the medical field. Descriptive analysis has brought individual differences into sharp focus, as few people have good sensitivity across all sensations, and this has lead to a greater understanding of sensory physiology.

1.5.2.3 Physico-chemistry
In attempting to understand the relationship between taste, odour and molecular structure using descriptive techniques, much effort has been put into identifying the chemical structure of molecules that may not otherwise have been investigated. Recently, this has been particularly true of naturally occurring compounds, particularly those with sweet taste such as stevia, the ability to block bitter taste and unique aromas.

It has been notoriously difficult to statistically link descriptive data to instrumental measures, particularly for food texture. This has lead to improvements in instruments, so that they better mimic in-mouth processes, such as mastication and flavour release.
1.5.2.4 Statistical Analysis

The need to analyse descriptive analysis data and combine them with other types of data has lead to the development of new statistical techniques, and contributed to a new field of statistics: sensometrics.

Initial descriptive analysis methods, flavor and texture profiling, did not use statistical analysis. It was first employed in QDA, when it was accepted that sensory data include inherent variability due to individuals. Classic descriptive analysis is typically analysed statistically using univariate techniques, such as ANOVA. The generation of data from scales of various types has necessitated new assumptions about the nature of the data generated, and hence adaptation of the techniques used. Sophisticated statistical analyses have also been developed to assess descriptive panel performance for discrimination, reproducibility and consensus. Considerable effort has been put into displaying descriptive data in a way that is understandable and meaningful to non-sensory scientists.

As descriptive techniques have evolved over time, so computing power has increased, and with it, the ability to combine descriptive data with other types of data to move from confirmatory to exploratory analyses. This has enabled the evolution and application of sophisticated modelling techniques and multivariate analysis, such as RSM, principal component analysis, GPA and preference mapping. More complicated studies have also necessitated the development of more sophisticated experimental design techniques. The increasing sophistication of modelling technique has, in turn, made the product design process more sophisticated. Software for sensory data collection, analysis and presentation continues to develop.

1.6 Summary

Descriptive analysis is undoubtedly one of the most sophisticated, flexible and widely used tools in the field of sensory analysis. Over the years, many techniques have been developed to meet different objectives and applications, each with their own advantages and disadvantages. Descriptive analysis plays an imperative role in industry, being utilized at all stages of a product’s life cycle from new product development to postlaunch monitoring to provide insights to research, marketing and QA/QC teams to help guide development, commercial, communication and maintenance strategy. Descriptive analysis is also used as part of multidisciplinary scientific investigations involving other fields for mutual benefit, such as food science, nutrition, physio-chemistry, psychophysics, psychology, physiology, neuroscience and genomics. A key aim of this multidisciplinary approach is to improve understanding of consumer perception, hedonics and behaviour. Descriptive analysis has continued to broaden its application from its roots in food and beverages to non-food categories.
1.7 Future Developments

It is anticipated that descriptive analysis will continue to develop faster and more flexible techniques, while seeking to improve the level of detail delivered and reduce the time required for data analysis. These will be combined and customized by users to develop techniques to meet their specific situations and test objectives. Research continues on newer, rapid methodology and Ares (2015) highlights particular areas for consideration: understanding the cognitive processes involved in samples evaluation, development of tools for evaluating reliability and the identification of limitations of new methodologies. There may well be a rise in the use of rapid methods with trained panels from traditional techniques to achieve the advantages of speed combined with reliability, reproducibility and improved interpretation of results. Technology will continue to impact development, so that testing in context and during real-time usage becomes commonplace, using tablets, mobile phones, apps and social media forums, etc. In short, descriptive analysis will maintain its place as a key technique in sensory evaluation, through its ability to adapt and enhance its capabilities and, hence, its usefulness.

1.8 Overview of Book

This book gives comprehensive coverage of time-static descriptive analysis. Descriptive techniques specifically designed to measure time-dependent changes in sensory properties are beyond the scope of this book, but are covered elsewhere (Hort et al. 2017). Descriptive techniques related to consumer hedonics, such as ideal and just-about-right profiling, are also beyond the scope of this book. The book is written by sensory scientists with industrial and academic backgrounds, selected for their expertise in descriptive analysis. It is organized into four sections.

Section 1, Introduction, covers the general principles of descriptive analysis. Chapter 1 gives an overview of descriptive analysis, and traces its evolution, applications and contributions. Chapter 2 addresses general considerations when conducting descriptive analysis, including psychological factors relevant to qualitative and quantitative assessment. Chapters 3 and 4 provide detailed information on panel set-up and training, and panel quality management (monitoring, performance and proficiency) respectively. Chapter 5 covers analysis of descriptive data.

Section 2, Techniques, consists of 12 chapters each detailing a descriptive technique, including an overview of its method, history, theory, analysis, practical considerations, advantages/disadvantages, applications, case studies and future directions. Chapters are generally in order of historical development, except in a few logically dictated cases. Traditional techniques covered are consensus methods (Chapter 6), original and modified/derivative profile methods (Chapter 7),
Quantitative Descriptive Analysis (Chapter 8) and the Spectrum Method (Chapter 9). The newer techniques covered are ranking and rank-rating (Chapter 12), free choice profiling (Chapter 13), flash profiling (Chapter 14), projective mapping and sorting methodologies (Chapter 15), polarized sensory positioning (Chapter 16) and check-all-that-apply (CATA) and free choice description (FCD) (Chapter 17). Many practitioners customize descriptive methods to meet their own specific requirements. Two examples are given based on traditional techniques: Quantitative Fragrance Profiling (Chapter 10) and the A^5daptive Profile Method (Chapter 11).

Section 3, Applications, consists of two chapters describing applications of descriptive analysis in food (Chapter 18) and non-food products (Chapter 19). Both chapters include general considerations, considerations related to specific products and examples.

Section 4, Summary, consists of a final summary (Chapter 20) that compares the descriptive methods from previous chapters and outlines future directions for descriptive analysis.

References


