

Sensory evaluation in the healthcare industry: a literature review

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Abstract

Sensory evaluation includes a wide variety of methods, and each method can range from a few to a large number. These methods can be used in the food and beverage industry, personal care, healthcare, and many other products. The objective is to review studies based on health and wellness of patients, products, and concepts, incorporating product efficacy to acceptability of sensory properties. The methods discussed in this review are discrimination (triangle test and paired-comparison test), descriptive analysis (consensus descriptive analysis and quantitative descriptive analysis), quantitative research (central location tests and home use tests), qualitative research (focus groups and one-on-one interviews) and emotion research (EsSense Profile®, MemVOC and emoSemio).

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Introduction

Sensory evaluations involve a set of techniques for accurate measurement of human responses. Also, sensory methods minimize the potential biasing effect of brand identity and other information that can influence consumer perceptions. The methods attempt to isolate the sensory properties of foods or non-food products and provide important and useful information to product developers, food scientists, and managers about the sensory characteristics of their products (Lawless & Heymann, 2010).

Sensory science has been used over the years to assess acceptance or rejection in food, beverage, and non-food categories. Factors such as nutritional knowledge, specific diets, emotions, health, and the nature of the products have important influence (Ruiz-Capillas, & Herrero, 2021). The healthcare industry can also benefit from a deeper understanding of consumers' perception of different products or topics. According to the Occupational Safety and Health Administration (OSHA), healthcare is involved, directly or indirectly, with the provision of health services to individuals. These services can occur in a variety of work settings, including hospitals, clinics, dental offices, out-patient surgery centers, birth centers, emergency medical care, home healthcare, and nursing homes. *Statista* reports that the projected revenue in the hospitals market worldwide is expected to reach US\$4.24 trillion (tn) in 2024. It is anticipated that the revenue will exhibit an annual growth rate of 3.42%, resulting in a market volume of US\$4.85tn by 2028. When compared globally, the United States is expected to generate the highest revenue, amounting to \$1,476 billion dollars in 2024 (Statista Market Insights, 2024).

A literature review has not been done to document how sensory analyses have been applied in the healthcare industry. It is critical to understand how sensory analysis can be used in the healthcare industry since this industry is immense worldwide. Different methods can be

applied not just to food or beverage but as well as to clinical products or patients. There are several sensory analyses that can be used to understand products and consumers' perception of food and non-food products. Two general categories of sensory evaluation exist which are analytical and affective. Analytical research includes discrimination and descriptive testing. Affective research is based on more subjective responses from naïve consumers which includes quantitative and qualitative research approaches. The most familiar discrimination tests are paired comparison, duo-trio, triangle, dual standard, and A-not-A. Descriptive analysis can be broken down into flavor profile, quantitative descriptive analysis, texture profile and sensory spectrum (Lawless & Heymann 2010). Quantitative research can be divided into acceptance, preference and attitudinal while qualitative research can be broken down into focus groups, one-on-one interviews and ethnographic research (Talavera, 2022). Discrimination testing is the easiest way to understand whether any perceptible differences exist in two types of products. This methodology does not provide specific characterization to understand the nature of the differences but only if differences are perceivable by consumers or not. In contrast, descriptive analysis measures specific characteristics to understand how products differ in specific sensory attributes. In descriptive analysis trained panels evaluate the products to identify and quantify sensory attributes. Affective research assesses hedonic measures of products to understand how well a product is liked or which product is preferred (Lawless & Heymann 2010). It also aims to explore the effect that various sensory characteristics may have on consumer acceptance. Affective research involves both quantitative and qualitative approaches. Quantitative research involves the use of scales for quantification of responses while qualitative research explores opinions, behaviors and attitudes towards products and concepts through focus groups discussions, one-on-one interviews and ethnographic research (Meilgaard et al., 2016). Emotional

research uses common experiential approaches to understand product effects on moods and emotions. Research indicates that many of our sensory experiences are infused with emotions which are an important feature of food choice and food consumption (Rodriguez & Kross, 2023). The following review discusses studies based on health and wellness of patients, products, and concepts, incorporating product efficacy to acceptability of sensory properties.

Review of the Literature

Discrimination Testing

Discrimination tests (also known as difference tests) are simple sensory tests that explore whether any perceptible difference exists between two types of products (Lawless & Heymann, 2010). These tests are suitable to determine whether product differences result from changes in ingredients, processing, packaging, or storage. Discrimination tests are also used to decide if an overall difference exists where no specific attributes can be identified as been affected. Finally, these tests are suitable to determine whether two samples are sufficiently alike and can be used interchangeably. Discrimination tests can also be used to select and train panelists and to monitor their ability to discriminate between test samples. There are different approaches to gather information about product differences. These approaches vary depending on product presentation and sample size. The methods include triangle, duo-trio, tetrad alternative/force choice (2-AFC test), simple ranking, etc. In a triangle test two samples are not visibly different. This method is particularly useful in situations where treatment effects may have produced product changes that cannot be characterized by one or two attributes. Alternative/force choice (2-AFC test) is one of the most used attribute tests. It is used to show which of two samples has more of the attributes being tested (Meilgaard et al., 2016).

Descriptive Analysis

Descriptive analyses are designed to identify and quantify specific sensory characteristics of any given product (Lawless & Heymann, 2010). This type of research relies on the use of trained panels to detect and identify specific sensory properties that are unique, descriptive, unambiguous, and discriminative to characterize products. These sensory properties represented as “attributes” will be defined to make sure there is clear understanding among evaluators and

stakeholders. This type of sensory method has proven to be the most comprehensive and informative tool. It is applicable to the characterization of a wide variety of product changes. The information gathered in descriptive analysis can be related to consumer acceptance information and to instrumental measures by means of statistical techniques such as regression or correlation. Descriptive tests are so diverse that they are often designed or modified for each individual application (Meilgaard et al., 2016).

Quantitative Research

Quantitative sensory testing methods are those that attempt to quantify the degree of liking or disliking of a product. The most straightforward approach to this method is to offer people a choice among alternative products and see if there is a clear preference from most consumers (Lawless & Heymann, 2010). Quantitative sensory testing can be divided into preference tests in which the task is to arrange the product tested in order of preference; acceptance tests in which the task is to rate the product or products on a scale of acceptability; and attribute diagnostics in which the task is to rank or rate the principal attributes that determine the products preference or acceptance. The 9-point hedonic scale is used to assess the liking and disliking of a product. The scale ranges from “like extremely” to “dislike extremely”. An example of this scale is shown in Figure 1 (Meilgaard et al., 2016).



Figure 1 Verbal hedonic scale

Qualitative Research

Several techniques can be used to probe “consumers’ response” to a new product or concept in addition to the traditional mode of using questionnaires and large statistical samples. Exploratory research methods, better known as qualitative techniques, often use a small number of consumers but allow for greater interaction and deeper probing of attitudes and opinions (Lawless & Heymann, 2010). Examples of qualitative research approaches include ethnography, grounded theory, phenomenology, and narrative research. Ethnography as a research design that has its origins in social and cultural anthropology, and involves the researcher being directly immersed in the participant’s environment. Grounded Theory is the generation of a theoretical model through the experience of observing a study population. Phenomenology is defined as the study of the meaning of phenomena or the study of the particular. Narrative research’s strength lies in its ability to tell a story, often from the perspective of those directly involved in it (Tenny et al., 2022). Qualitative effective tests like interviews, focus groups, and observational research are those that measure opinions, behaviors, and attitudes of a sample of consumers to product concepts, ideas, services, products, etc. This is accomplished by probing consumers to discuss

their feelings and opinions in various settings, which can be done at home or in a central location (Meilgaard et al., 2016).

Emotion Research

Decades of evidence reveal intimate links between sensation and emotion. Yet, discussion of sensory experiences as tools that promote emotion regulation is largely absent from current theorizing on this topic. Common experience and research indicate that many of our sensory experiences are infused with emotion. Part of the reason why sensation is so remarkably effective at informing whether to approach or avoid stimuli is because of its ability to activate brain networks that produce emotional responses. Once incoming sensory input reaches the appropriate sensory cortex (i.e., auditory, visual, gustatory, olfactory, or somatosensory), neural signals project rapidly and directly to brain regions that are centrally involved in generating emotional responses. The ability of sensation to activate brain regions that support emotional processing is crucial for survival. For instance, upon detection, tastes are immediately encoded as appetitive or aversive to promote nutrition and survival. Bitter and sour tastes ensure that poisonous and rotten food is not ingested, and sweet and salty tastes ensure that our bodies receive crucial nutrients. In sum, part of why sensory input rapidly activates emotion is to promote survival. Taken together, these diverse sets of findings demonstrate that the process of sensation is intimately linked with our experience of emotion. Furthermore, evidence indicates that sensation can also influence emotion via indirect pathways, such as diverting attention, promoting cognitive reframing, and activating autobiographical memories which can have an important effect in product choice, purchase, and consumption (Rodriguez & Kross, 2023).

Methodology

This literature review provides a summary of findings on sensory evaluation as specifically related to health and wellness. This review is aimed at benefiting the sensory and health department as well as the students at Kansas State University. Since it will give them an overview of how sensory analyses can be used in the health industry. The sensory methods discussed in this literature review are discrimination, descriptive, quantitative research, qualitative research, and emotion research.

Findings

Discrimination Testing

There are two groups of difference tests which are overall difference tests and attribute difference tests. Overall differences such as the triangle test or tetrad are designed to show whether panelists can detect any difference at all between samples. On the other hand, attribute difference tests such as paired comparison tests asked the subjects to concentrate on a single attribute or a few attributes (Meilgaard et al., 2016).

The triangle test is one of the most used discrimination methods due to simplicity of the task, relative ease of preparation, and analysis (Williams et al., 2016). In a triangle test three samples are presented simultaneously to the panelists where two samples are from the same formulation, and one is different. Each panelist must indicate which sample is odd or which two samples are most similar. The usual form of the scoresheet asks the panelist to indicate the odd sample (Lawless & Heymann, 2010). This method is used when the test objective is to determine whether sensory differences exist between two products. Triangle testing is particularly useful in situations where treatment effects may have produced product changes that cannot be characterized simply by one or two attributes. An example of a triangle test scoresheet is provided in Figure 2 (Meilgaard et al., 2016). The tetrad test is used when two samples do not have obvious visible differences and differences are small. Although the unspecified tetrad test has equal guessing probability to that of the triangle test, the theoretical power under the Thurstonian model is greater for the tetrad test. Therefore, the tetrad will theoretically have greater power and sensitivity with the same number of panelists. However, a scientific poster written by William et al. (2016) found that that there is not a significant advantage to using the tetrad method in place of the triangle method with the type of products tested, either with high

potency sweeteners or without them. These results suggest the advantage of the tetrad method over the triangle method may be product-specific (Williams et al., 2016).

Triangle Test		
Name _____ Date _____		
Type of Sample _____		
Instructions Taste samples from left to right. Two are identical; determine which is the odd sample. If no difference is apparent, you must guess.		
Sets of three samples	Which is the odd sample?	Comments
_____	_____	_____
_____	_____	_____
_____	_____	_____

Figure 2 Example of score sheet for three triangle tests.

Directional difference test is used when the test objective is to determine in which way a particular sensory characteristic differs between two samples (i.e., which sample is sweeter?). This method is also called paired-comparison test or the 2-alternative forced choice (2-AFC) test. It is one of the simplest and most used sensory tests and is often used first to determine if other more sophisticated tests should be applied (Meilgaard et al., 2016). The two samples are presented to the panelists simultaneously and the panelists are asked to identify the sample that is higher in the specific sensory attribute. The panelist must clearly understand what the sensory scientist means by the specified dimensions. Panelists should be trained to identify the specified attribute and to perform the task as described by the scoresheet (Lawless & Heymann, 2010). An example of a scoresheet of a directional paired comparison test is provided in Figure 3 (Qian & May, 2017).

Directional Paired Comparison test

Assessor No: _____

You are provided with two strawberry flavor drinks, each labeled with a three-digit code.

Please assess each product in the order provided, from left to right.

Please indicate which of the samples has the most strawberry flavor by circling the corresponding sample code below.

You are NOT allowed to re-taste the samples.

Please cleanse your palate with water and crackers between samples.

Sample 375 / 194 has the most strawberry flavor

Any comment: _____

Figure 3 Example of questionnaire of directional paired comparison test.

Mata et al. (2007) conducted research to understand the correlation between personality traits and the discrimination ability of test subjects. The 16-personality factors questionnaire of Cattell was applied to 143 participants. The judge's performance was evaluated following a series of taste and odor tests. Judges were then asked to rank basic different taste solutions. Finally, judges discriminated between purified water and a low intensity sweet solution using the triangle test. Results showed that, out of 143 participants, 66 were found discriminators. Two personality traits were correlated to sensory discrimination ability. The serious type of personality was correlated to discriminators, while the experimenting type of personality correlated to non-discriminators. These results suggest the importance of using personality trait tests during sensory judge selection (Mata et al., 2007).

According to research conducted by Ronteltap et al. (2004) a double-blind placebo-controlled food challenge (DBPCFC) is the golden standard for the diagnosis of food hypersensitivity. It is necessary that recipes comprising the allergens cannot be distinguished from placebo. It was investigated whether the method of paired comparisons, a sensory

difference test, could be used to test the suitability of recipes for a DBPCFC. Two recipes were used, each with three concentrations of peanut or hazelnut flour. Recipes were offered together with a placebo and evaluated on sensory features by 81 healthy volunteers. Volunteers were not able to detect peanut flour in mashed potatoes, but they recognized hazelnut flour in oatmeal porridge on visual features. Sensory testing by means of the method of paired comparisons is a useful method to evaluate masking of foods for DBPCFC (Ronteltap et al., 2004).

Descriptive Analysis

Consensus descriptive analysis and Quantitative Descriptive Analysis (QDA) are two different approaches to descriptive analysis. Both involve trained panelists who evaluate products for their individual properties. The outputs from each approach look similar in that you get a qualitative set of attributes or terms with each having a quantitative numerical score or rating associated with each attribute or term. The differences lie in the amount of training, type of attributes or terms, use of references and stability of the method over time.

Quantitative Descriptive Analysis (QDA) was developed during the 1970's to correct some of the problems with the Flavor Profile (FP) analysis. In contrast, to FP and QDA, the data are not generated through consensus discussion, panel leaders are not active participants and unstructured line scales are used to describe the intensity of rated attributes (Lawless & Heymann, 2010). This sensory descriptive analysis method relies heavily on statistical analysis to determine the appropriate terms, procedures, and panelists to be used for the analysis of a specific product. Panelists are selected from a large pool of candidates according to their ability to discriminate differences in sensory properties. They are trained on samples of a specific product type and require the use of product and ingredient references to generate the terminology (Meilgaard et al., 2016).

Descriptive data can be generated individually in replicate by each panelist to be later analyzed using univariate or multivariate statistics to assess noise to signal ratios or by consensus which is more of a “group” output. The size of trained panels will vary between 6 – 12. Common to all consensus descriptive methods is the idea that individuals evaluate products and then discuss the attributes and/or intensities to determine an agreed-on description of the product in question. The consensus method is less sensitive and can be used in scenarios where large differences exist. A unique use of the consensus method is in developing 'identity profiles'. In consensus methods, panelists are encouraged to identify, reference, and score new attributes during the test (Chambers, 2018).

An article written by Chambers et al. (2022) evaluates the “Sensory Profiling and External Preference Mapping of Pre-Thickened Water Products for Dysphagia”. Pre-thickened ready-to-serve products generally appear to provide appropriate texture and provide some differentiation in flavor among the products tested in this study. In some cases, pre-thickened liquids may be better options for patients with dysphagia than instant thickening agents since they do not need preparation and may provide fewer off-flavors than instant thickeners. However, to ensure patients receive the product at the most appropriate consistency, manufactures should reach a better agreement on the viscosity for each consistency, especially the difference between multiple consistencies of the same products. In this study, consensus descriptive analysis showed that a nectar-like product from one company had a similar viscosity as a honey-like product from another company, which does not respect guidelines, such as the National Dysphagia Diet (NDD) or International Dysphagia Diet Standardization Initiative (IDDSI) guidelines in place for healthcare providers. It is important to give patients products that match the patients’ swallowing needs. Since it may be difficult or impossible to adjust the

viscosity of the pre-thickened beverage, it can be potentially dangerous for patients if manufacturers produce products with dramatically different texture but label them similarly. To help improve the acceptance of the consumers for the pre-thickened water products this study showed that the addition of sweetness and flavor, such as lemon flavor, is recommended (Chambers et al., 2022).

An article written by Withers (2013) outlines the “Sources, Mechanism and Perception of Mouth Drying in Oral Nutritional Supplement Beverages”. Oral Nutritional Supplements (ONS) are nutritional status enhancing beverages prescribed to older adults at risk of under-nutrition. They contain energy, protein, vitamins, and minerals; however, the low consumption of ONS on elderly care wards can prevent patients from receiving their health benefits. The predominant cause for beverage wastage has been reported to result from patients disliking the taste. This study investigated the key sensory attributes of ONS, aiming to understand and reduce the negative characteristics to improve ONS products and enable increased consumption by older patients. The sensory characteristics were assessed with a trained panel by both quantitative descriptive analysis (QDA) and sequential profiling, as well as directly with older adults through a novel use of a taxonomic free sorting (TFS) technique which is a technique that aims to determine the sensory characteristics of products that are important to specific consumer cohorts (Withers et al., 2014). The results from TFS were directly relatable to QDA, even though the participants were untrained, and the sorting data was combined with liking data to yield a preference map generated entirely from target consumer data. Interestingly, older adults were more sensitive to perceived mouth drying than younger adults, a critical attribute found in ONS during repeated consumption. Sequential profiling with a trained panel assessed a range of ONS dairy protein ingredients to find potential sources of mouth drying. Although whey protein

concentrate was found to be the most drying ingredient, all protein powders elicited some drying. Through a wide range of techniques this study highlighted mouth drying as a key detectable attribute of ONS. Although masking methods were not able to reduce the drying sensation, the breakthrough of mucoadhesion between dairy proteins and the oral mucosa suggests this attribute could be further investigated and reduced to improve ONS consumption by older patients (Withers, 2013).

Quantitative Research

Quantitative affective tests are more hedonic in nature and require the use of untrained subjects who are familiar with the product under evaluation to provide relevant information. Because the measurement of “liking” is more subjective and will be largely dependent on respondents’ background and demographics, a larger group of consumers will be needed, which can range from N=50 to several hundred. The questions asked are regarding choice, preference, liking, sensory attributes, etc. These methods are used to determine overall preference or liking for a product or products by a sample of consumers who represent the population for whom the product is intended. Affective tests are also used to determine preference or liking for broader aspects of product sensory properties such as aroma, flavor, appearance, texture, aftertaste, etc. Finally, quantitative affective tests are used to measure consumers response to specific sensory attributes of a product which can also be referred to as “diagnostic” research. Use of intensity, hedonic, or “just right” scales can generate data that can be related to the hedonic ratings and to descriptive analysis data to ultimately help product developers to design and improve products with optimized liking (Meilgaard et al., 2016).

The test location or testing site has numerous effects on the results of sensory testing. This is due to its geographic location but also because the place in which the test is conducted

defines several other aspects of product sampling and perceived sensory properties. Some of the advantages of laboratory testing, also known as central locations tests (CLT) are that product preparation and presentation can be carefully controlled, subjects can be contacted on short notice to participate and color or other visual aspects that may not be fully under control in prototypes can be masked so that the subjects can concentrate on the flavor and texture differences under investigation. Some of the disadvantages of laboratory tests include the lack of normal consumption, which may influence the detection or evaluation of positive or negative attributes, and standardized preparation procedures and handling protocols might not necessarily mimic consumer behavior and experiences at home (Meilgaard et al., 2016).

The most expensive but most realistic situation is when consumers take the product home and try it under normal circumstances on several occasions. Home use tests (HUT) are time consuming to set up and administer. HUTS offer tremendous advantages in terms of face validity of the data (Lawless & Heymann, 2010). The participants are selected to represent the target population. The entire family's opinion can be obtained, with the influence of one family member on another. In addition to the product itself, the HUT provides a check on the package to be used and the product preparation instructions, if applicable. Typical panel sizes are 70-300 per cell. Often, two or three products are compared. The first is used for 4-7 days and its corresponding score sheet is completed, after which the second is supplied and rated, and so forth (Meilgaard et al., 2016).

An example of a CLT was conducted by Alencar et al. (2017) who wanted to understand the "Sensory characterization of gluten-free bread with addition of quinoa, amaranth flour and sweeteners as an alternative for coeliac patients". This study aimed to determine the acceptance of gluten- and sucrose-free breads with addition of pseudocereals and sweeteners, characterize

them using quantitative descriptive analysis (QDA) and identify the drivers of liking using four different techniques of sensorial data evaluation. A consumer test with 118 panelists was performed, and a QDA was carried out by 12 trained assessors to obtain the sensory profile. Sessions were held at the Laboratory of Sensory Science and Consumer Study of the Food and Nutrition Department (School of Food Engineering/University of Campinas). The incorporation of amaranth, quinoa and sweeteners in gluten- and sucrose-free breads did not influence the texture of the samples, and breads obtained were moderately accepted. Gluten and sucrose-free breads with the addition of amaranth were the most preferred by the consumers indicating that amaranth is a potential substitute for incorporation in gluten-free bakery products (Alencar et al., 2017).

The article written by Adam (2020) gives an example of a HUT. This study is called “Introducing the Oral-B iO electric toothbrush: next generation oscillating-rotating technology” describes the development of a toothbrush with a linear magnetic drive, resulting in oscillation-rotations with micro-vibrations. The brush has a redesigned round brush head and smart pressure sensor to enhance plaque removal and encourage proper brushing technique. The plaque removal and gingival health effects of this new electric toothbrush technology were evaluated in three randomized controlled studies, including an 8-week trial versus a manual toothbrush, an 8-week trial versus a premium sonic toothbrush, and a single-brushing, repetitive-use study versus a manual toothbrush. Real-time brushing encouragement was communicated via a unique intuitive smart interface, and a menu of features promotes compliance through coaching on brushing time, location, and pressure. Consumers also experienced interaction by using artificial intelligence for guidance in a two-minute brushing session with 3D teeth tracking, via an Oral-B iO app with Bluetooth connectivity, without having to bring their smartphone into the bathroom or mount it

on the mirror. Outcomes from these studies demonstrate statistically significantly greater plaque removal and gingival health improvements for the Oral-B iO toothbrush technology versus manual and sonic toothbrush controls. Plaque removal advantages demonstrated in the replicate-use single-brushing trial resulted in significant gingival health benefits as evidenced in the longer-term trials. The brush provides a noticeably quieter brushing experience, which some consumers find appealing (Adam, 2020). Zampini et al. (2003) investigated the perception of an electric toothbrush on the sound effects. Subjects were required to make stereotypical brushing movements with an electric toothbrush while rating either the pleasantness or the roughness of the vibrotactile stimulation they felt on their teeth. The results demonstrate that the perception of sensations experienced during toothbrush use were systematically altered by variations in the auditory feedback elicited by the brushing action. Participants reported that the toothbrush felt more pleasant and less rough when either the overall sound level was reduced, or when the high-frequency sounds were attenuated (Zampini et al., 2003).

Qualitative Research

Qualitative research asks open-ended questions whose answers are not easily put into numbers such as ‘how’ and ‘why’. Due to the open-ended nature of the research questions at hand, qualitative research design is often not linear in the same way quantitative design is. One of the strengths of qualitative research is its ability to explain processes and patterns of human behavior that can be difficult to quantify. Phenomena such as experiences, attitudes, and behaviors can be difficult to accurately capture quantitatively, whereas a qualitative approach allows participants themselves to explain how, why, or what they were thinking, feeling, and experiencing at a certain time or during an event of interest. Quantifying data is looking for themes and patterns that can be difficult to quantify and is important to ensure that the context

and narrative of qualitative work are not lost by trying to quantify something that is not meant to be quantified (Tenny et al., 2022). Different qualitative methods can be used to meet specific project objectives or needs. Focus groups and one-on-one interviews are used to understand consumers thoughts and opinions regarding a specific topic of interest. According to Austin & Sutton (2014) Qualitative research was historically employed in fields such as sociology, history, and anthropology. However qualitative methods can be implemented in other fields or industries, for example food, beverages, healthcare, and cosmetics. There are various research studies that have been published regarding qualitative research such as focus groups and one-on-one interviews on the healthcare industry with the incorporation of sensory science and consumers/participants experiences.

Focus groups are the most common form of qualitative research which is an in-depth group interview or focused group discussion. They typically involve 6-8 consumers sitting around a table and discussing a product or idea with the seemingly loose direction of a professional moderator (Lawless & Heymann, 2010). The moderator presents the subject of interest and facilitates the discussion using group dynamics techniques to uncover as much specific information from as many participants as possible. Usually, two or three sessions are conducted which are all directed toward the same project focus. This is done to determine any overall trend of responses to the concept and/or prototypes (Meilgaard et al., 2016).

Sometimes one-on-one interviews are the most appropriate approach to gather information of interest. This is usually necessary when the issue is very personal, emotionally charged, or involves experts who are better probed individually (Lawless & Heymann, 2010). This method is often called in-depth interviews (IDIs). The interviewer conducts successive interviews with anywhere from 12-50 consumers, using a similar format but probing in response

to each consumer's answers. One-on-one interviews or observations of consumers behaviors can provide researchers insights into unparticular or underlying consumer needs. This can lead to innovative products or services that meet such needs (Meilgaard et al., 2016).

Focus groups were used by Parmar et al. (2021) on a study called "Visual Sensory Experiences From the Viewpoint of Autistic Adults". This study focusses on characterizing autistic visual sensory symptoms, contextualizing their impact, and documenting any associated coping strategies. 18 autistic adults took part in focus groups which involved questions around visual experiences, the impact of these on daily life, and strategies for their reduction. Transcripts of each session were thematically analyzed which resulted in six key themes. Participants described a range of visual hypersensitivities, including light, motion, patterns, and particular colors, which contributed to distraction and were frequently part of a wider multisensory issue. Such experiences had significant negative impacts on personal wellbeing and daily life with participants describing fatigue, stress, and hindrances on day-to-day activities like traveling and social activities. However, the degree of understanding that participants had about their visual experiences influenced their emotional response, with greater understanding reducing concern. The findings have confirmed that autistic adults are often dissatisfied with their vision and experience a range of visual sensory symptoms which vary from person to person. These symptoms can occur alone or as part of a larger multisensory response, nevertheless, vision contributes to sensory issues and emotional responses. Participants employed a variety of coping strategies to overcome visual sensory experiences but with varied success. It was also highlighted that there may be a poor public understanding of sensory issues in autism affecting how well autistic individuals are able to manage their sensory symptoms. Autistic adults expressed significant concern about their visual experiences and there is a need to improve

understanding of visual experiences on a personal and public level as well as for developing potential support (Parmar et al., 2021).

Another example of focus groups was used by Balza et al. (2022) in which they wanted to understand the barriers to care for refugee patients. Although the present article is not specifically related to product experience, the author still considers it as consumer (refugee patients) experience and therefore included in this review. Refugee populations resettled in the United States face health disparities and barriers to accessing care. Better understanding of the barriers this population faces may help clinicians address them. Focus groups with refugees were held in Wisconsin. The 7 groups ranged from 5 to 15 participants (mean= 9) and were organized by language (Arabic, Burmese, Chin, Karen, Rohingya, and Somali). Discussion prompts such as “What could be done to improve health in your community?” were used. Notes from the focus groups were organized and coded using MAXQDA software. Six themes were identified from the focus groups regarding health care barriers and experiences: language, interpretation, pharmacy, insurance, transportation, and respect. Subjects described language as a barrier in different ways: making appointments, understanding voicemails and voicemail menus, provider communication, and filling forms. Related to but distinct from language barriers, participants described challenges regarding interpretation: insufficient time, discordance in dialect, perceiving that the interpreter was not communicating everything, and fear of breach of confidentiality if from the same community as the interpreter. Subjects described barriers related to pharmacies: not understanding refills, prescriptions not being covered, and no interpretation. Participants acknowledged the essential need for insurance but also described challenges: misunderstanding its use and limitations, difficulty navigating plans, difficulty resolving billing errors, insufficient insurance when changing to an employer plan, and difficulty accessing

noncovered prescribed medications. Subjects described ways in which transportation was a barrier: lack of a car, not knowing the clinic location, difficulty navigating roads. Some participants reported receiving respectful care, others reported disrespectful treatment. Clinicians working with refugee populations can strive to minimize barriers to care for refugee patients by being aware of the barriers, implementing changes in their practice, and/ or community advocacy (Balza et al., 2022).

One-on-one interviews were used in research conducted by Bas et al. (2021) the article is called “Experiences of Adults High in the Personality Trait Sensory Processing Sensitivity: A Qualitative Study”. Sensory processing sensitivity (SPS) is a personality trait reflecting inter-individual differences in sensitivity to negative and positive environmental information. High SPS is associated with increased stress-related problems if environments are unfavorable but also appears to enhance one’s ability to benefit from health-promoting environments. This study reported the perceptions and experiences of SPS characteristics in adults high in this trait. Semi-structured interviews were analyzed thematically and described. Six themes emerged: (1) emotional responding; (2) relatedness to others; (3) thinking; (4) overstimulation; (5) perceiving details; and (6) global SPS characteristics. With regards to coping with negative consequences of high SPS, the main themes were: (1) reducing sensory input and (2) psychological strategies. Fine-grained information was gained on experiences of adults high in SPS and derived new hypotheses regarding the fostering of well-being related to high SPS. This study broadens the horizon on the theoretical perspective on SPS as well as a more practical view on coping with the negative sides of SPS and the well-being of individuals high in SPS.

Another example of one-one interviews was conducted by Liddy et al. (2015) on “Improving awareness, accountability, and access through health coaching Qualitative study of

patients' perspectives". Even though the indicated study is not specifically related to product experience, the author still considers it as consumer/patients experience and for that reason is included in this literature review. The objective of this study was to assess patients' experiences with and perceptions of health coaching as part of their ongoing care. A qualitative research design was conducted by using semi-structured, one-on-one interviews that were recorded and transcribed verbatim. Interviews were conducted in English, French, or Somali at Ottawa, Ont. Eleven patients enrolled in a health coaching pilot program who were at risk of or diagnosed with type 2 diabetes. Participants' perspectives were assessed with semi-structured interviews. Interviews were conducted with 11 patients at the end of the pilot program, using a stratified sampling approach to ensure maximum variation. Stratified sampling is when the researcher samples specific proportions of individuals from various subpopulations (strata) in the larger population. This is meant to ensure that the subjects selected will be representative of the population of interest (Tal, 2011). When asked to describe their overall experience with the health coaching program, all 11 patients said it was positive. Subjects believed the health coaching program was effective in increasing awareness of how diabetes affected their bodies and health, in building accountability for their health-related actions, and in improving access to care and other health resources. Coaches provided patients with advice on a range of issues, including pain management, diet, and vitamins. Patients expressed a high degree of confidence in the coaches' ability to answer their questions and help them meet their health goals. Patients' reported experience suggest that this program supports the foundations for behavioral change by specifically affecting attitudes toward self-management and, perhaps equally important, increasing patients' perceptions of their ability to manage their own care through increased access, awareness, and accountability. Participants perceive one-on-one health coaching as an

acceptable intervention in their ongoing care. Patients enrolled in the health coaching pilot program believed that there was an improvement in access to care, health literacy, and accountability, all factors considered to be precursors to behavioral change (Liddy et al., 2015).

A final example of interviews was conducted by Wang & Chung (2012) which focused on “Breast Cancer Survivors’ Efforts to Renew and Preserve Their Health in Taiwan”. Although the specified article is not specifically related to product experience the author still considers it as consumer (breast cancer survivors’) experience and as a consequence is included in this review. This research was designed to describe the personal life experiences of breast cancer survivors regarding their efforts to recover and preserve their health. Three common themes emerged from the one-on-one interview which were introspection on the cause of cancer, realization of a harmonized lifestyle, and reflecting on the strong will to survive. The results show breast cancer survivors’ experiences addressing the threat of cancer and their efforts to preserve their health. Most participants reported understanding the factors involved in their development of cancer and were aware of too much fat and meat in their diets. Additionally, they generally did not exercise enough. They slept too little, experienced emotional instability and stress, and indulged in bad habits. Some subjects adopted a healthier lifestyle, such as a healthy diet, detoxification, actively exercising, enjoying the fun of life, seeking an environment with a good magnetic field, and helping their bodies to restore their health. Participants were helped in their cancer survival efforts by choosing healthy foods, consuming a light diet with plenty of fruits and vegetables, and by simplifying their cooking. Spiritual enlightenment and religion were also effective means for cancer survivors to cope with their disease. The results clarify the relationship between breast cancer survival and individual efforts to restore and preserve health (Wang & Chung, 2012).

Emotion Research

Understanding product performance, traditional sensory and consumer research has always focused on the relationship between sensory perceptions and liking measures. In these days of extremely competitive markets, some studies have highlighted that using hedonic measurement alone is inadequate for measuring the consumer affective product experience. Consumers very often rely on unconscious emotions associated with a product via sensory perceptions to make their purchase or consumption decisions. The knowledge and capability to define, measure and understand how emotions relate to specific products and brands via sensory attributes could ultimately provide a decisive and competitive advantage in the marketplace (Ng & Hort, 2014). The EsSense Profile[®], MemVOC and EmoSemio are available tools specifically developed to measure sensory characteristics, emotions, and memory response of consumers in relation to various stimuli. These methods are gaining popularity due to the incorporation of consumer emotions into product understanding.

The EsSense Profile[®] methodology incorporates both overall acceptability and emotion measures in the consumer test questionnaire. This method provides a detailed list of emotional attributes that consumers associate with the test products. This list can be expanded or edited to account for specific emotions that may be appropriate in specific product categories and in specific applications. Data collection can be completed using check all that apply (CATA) or data scaling (King et al., 2010).

Multiple references in sensory science indicate that foods evoke memories during consumption, however, research regarding those memories is still limited. Memories Vocabulary (MemVOC) can help to understand the impact of food on the consumer's memories, which allows for the generation of a new paradigm for a comprehensive characterization of food

including sensory characteristics, memories, and emotions. Their proposal is to use a memories vocabulary to help respondents retrieve those memories in a systematic way that can be further analyzed using a diversity of statistical techniques (Cabal-Prieto et al., 2022).

EmoSemio is extended to cover not only emotions but also sensory properties and uses. This protocol aimed at developing an emotion product-specific questionnaire based on interviews with consumers which may be applied with different product categories. The originality of the method is twofold: 1) the design of the interviews and 2) the use of semiotic analysis to interpret the information and to develop the questionnaire (Spinelli et al., 2019).

An example of EsSense profile and MemVOC memory vocabulary were used in the research called “Effects of COVID-19 on sensory and cognitive perception of mild and severe diagnosed and recovered patients versus healthy consumers”. Three groups of 50 consumers each (healthy vs. mild and severe COVID-19 diagnosed with 30 days after recovery) were used for the evaluation of instant coffee stimuli in different concentrations and to determine their discriminating power, emotions, and memories. There were no significant differences between healthy consumers and consumers who suffered mild or severe COVID-19 for the identification of sensory attributes. Consumers of P-Healthy perceived the highest intensities in most sensory attributes compared to those from the PCOVID19-Mild and PCOVID19-Severe panels. However, regarding discrimination, it was found that consumers diagnosed with COVID-19 discriminated 5 sensory attributes (smell, basic tastes, and flavor) compared to the panel of healthy consumers who could only discriminate in two attributes (basic tastes). Likewise, consumers diagnosed with mild or severe COVID-19 used a higher number of emotions (14 positive and 6 negative) and memories (14 positive and 8 negative) than those from the healthy panel who used 10 positive emotions, 5 negative emotions, 10 positive memories and 5 negative

memories. In both emotions and memories, consumers of the PCOVID19-Mild and PCOVID19-Severe panels elicited more positive and negative emotions and memories compared to the consumers of the P-Healthy panel. This result can be attributed to the consumers recent COVID-19 process, although the temporality (times higher than 30 days) of the elicited emotions and memories due to a COVID-19 traumatic event is unknown. These results could also be an effect of regulation of the mood of people who suffered from the COVID-19 disease (Cabal-Prieto et al., 2023).

An example of EmoSemio method is the study conducted by Lagerkvist et al. (2016) called “Nutrition promotion messages: The effect of information on consumer sensory expectations, experiences and emotions of vitamin A biofortified sweet potato”. The study investigated how information about vitamin A biofortification influences the expected and actual sensory evaluation and the emotions evoked through actual tasting. Vitamin A deficiency (VAD) is a major public health problem in many developing countries globally. It is estimated that 250 million children under the age of five years suffer from clinical VAD. The effects of VAD include eye damage, weakened immunity and general increases in the incidence and severity of infectious diseases and mortality. Biofortification is an essential strategy to alleviate VAD by incorporation of micronutrients into food staples through conventional breeding processes. However, vitamin A biofortification involves changes in other product attributes such as color and taste that may be undesirable to some consumers. This study investigated how information about vitamin A biofortification influences the expected and actual sensory evaluation and the emotions evoked through actual tasting. The research demonstrated the influence of information effects on the emotional status level evoked by the consumers after tasting. One group (Control) received only general information on the agronomic properties of the biofortified sweet potato

variety, whereas in addition to the agronomic information, the other groups received either detailed information on vitamin A, which was the Nutrition group, or on negative product sensory aspects of orange-flesh sweet potatoes compared with white and yellow varieties which was the Drawbacks group. An EmoSemio profile was used to measure and compare the emotional profile of each treatment group after the actual testing. Items were measured on a 5-point scale from “not at all” to “extremely”. The profile uses full sentences instead of the single adjectives employed in the well-established EsSense profile and therefore provides a clearer and more contextual way to express emotions. An example of a full sentence is “It is an anti-stress, it calms me, it soothes me, it reassures me, etc. The results showed that detailed information about nutritional benefits decreased consumer acceptance. Information about attribute drawbacks had discriminatory effects only in relation to expected taste and experienced texture. The findings indicated that the appropriateness of the nutritional aspect of orange-fleshed sweet potato was related to the information treatment and to household food insecurity status, but not to income or age of participants. The levels of eight positive emotions in the Nutrition group exceeded the levels within the Drawback group, and no significant difference was found for the negative emotions. This not only indicates that there were information effects on the emotions that do not correspond to the sensory assessment, but also that the emotions that were discriminating between the positive and the drawback information can be used to underpin the provision of nutritional information. These results raise important questions relating to how nutrition information should be provided to generate consumer acceptance and adoption of orange-fleshed sweet potato. This finding is of interest to product developers and potential marketers because nutritional information combined with tasting is positively weighted and integrated by the individual to form emotion elements that can be associated with product acceptance. It

corroborates the argument on combining orange-fleshed sweet potato promotion efforts with demonstration and product tasking. More importantly, the influence of food tasting on emotions demonstrated here suggests that merely measuring just about right or liking is insufficient for the prediction of acceptance (Lagerkvist et al., 2016).

Discussion

Sensory evaluation in the food and beverage industry is similar in some respects to the health care industry, but also different in many other ways due to the addition of stimuli with many other traits beyond the measurement of flavor and texture acceptance of food or beverages. Many products in the healthcare industry will have efficacy aspects that are as important, as well as physiological and psychological components that add many layers to the concept of product experience, food choice and/or food intake.

According to the article written by Shepherd (1999) the factors influencing food choice are categorized as 1) those related to the food, 2) those related to the individual making the decision to purchase and consume the product and 3) those related to the external economic and social environment within which the decision is made (Figure 4). Some of the chemical and physical properties of the food will be perceived by the individual in terms of sensory attributes, (e.g. flavor, texture, or appearance). However, perceiving these sensory attributes in a particular food does not necessarily mean that an individual will or will not choose to consume that product. Rather, it is the individual's perception of those attributes that will be the determining factor (perception which can be affected by other physiological and psychological factors). Chemical and nutritional components in foods, such as the amount of protein or carbohydrates, will influence the individual, (e.g. reducing hunger, and the learning of the association between the sensory attributes of a food and its post-ingestion consequences appears to be a major mechanism by which preferences develop). Psychological differences between individuals, such as personality, experience, moods, emotions, and beliefs, may also influence food choice (Shepherd & Farleigh, 1986).

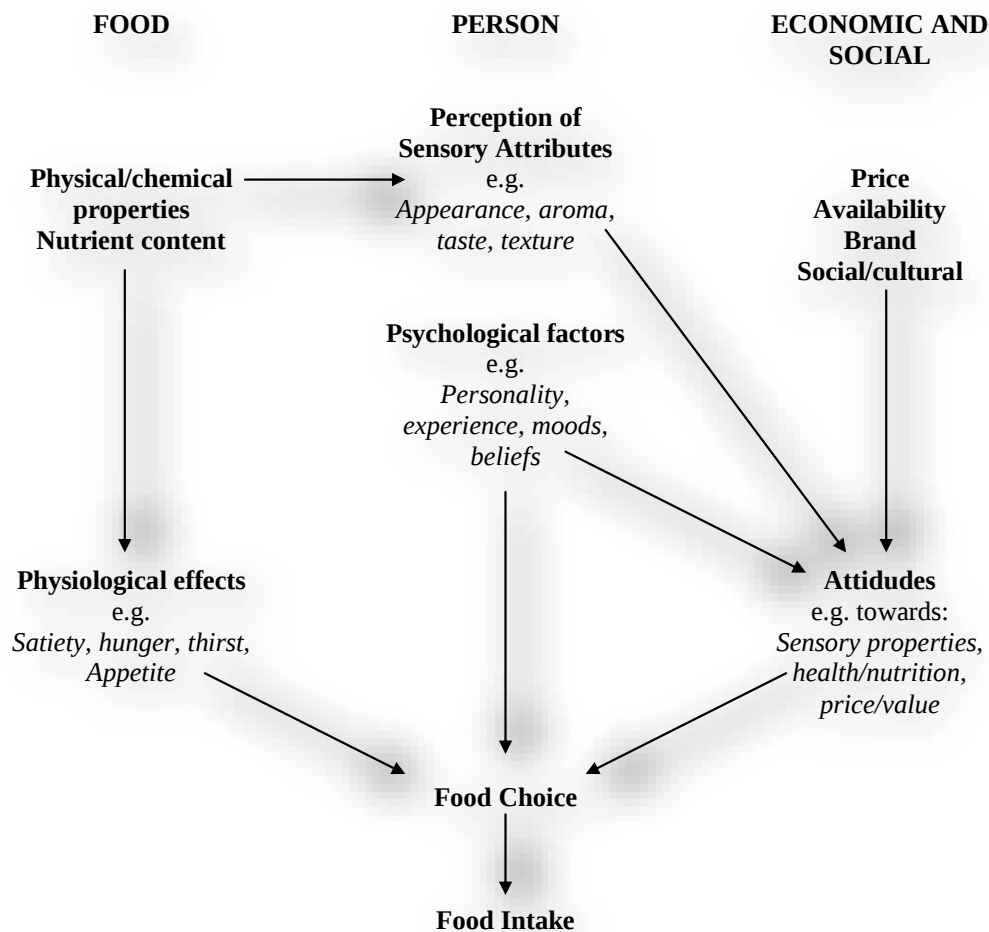


Figure 4 Some factors influencing food choice (Shepherd, 1985)

According to the overview article written by Prescott (2017), a recent trend in sensory and consumer research has been to measure emotions and determine the extent to which feelings are linked to consumers' acceptance of foods and other consumer products. However, behavioral and neuroscience researchers have not been able to exactly specify the nature, content, or attributes of emotions after more than a century of formal investigation. This should be reason enough to prompt a pause before presenting consumers with a list of emotional words in the hopes that this will aid in the future development and commercialization of consumer products. It is argued that many of our routine ideas about emotions lack scientific evidence and that it is

unclear when asking consumers to rate their emotions what kinds of data are being provided. A conservative and scientifically supportable way to proceed in sensory and consumer research is to focus primarily on the measurement of core affect, namely valence and arousal, and at the same time measure important contextual and individual difference variables which have been shown to be crucial to the construction of individual emotions. Valence describes the extent to which an emotion is positive or negative, whereas arousal refers to its intensity. That aside, it is recognized that emotion states are powerful drivers of behavior and are key in promoting preferences and reinforcing memories, particularly those related to odors and flavors (Prescott, 2017).

Another article written by White (2020) suggests that sensory and consumer research often focuses more on bottom-up than top-down influences on consumers' perception and acceptance of foods. However, cognitive processes create and transform incoming sensory information originating from separate senses which includes olfaction, gustation, and somatosensation, into the perception of flavor. The article discusses five cognitive processes that affect human chemosensory perception and responses to food flavors: attention, language, memory, learning, and metacognition. It is argued that each of these processes are important in shaping interactions with food via the chemical senses. Attention moderates' perception through its distribution across the environment by fine-tuning it for a particular stimulus. Language affects food acceptability and preference, as does the memory of prior experiences with a food, even when they are not at a conscious level of processing. Interactions among smells, tastes, and textures are acquired through learning, as are hedonic properties. Metacognitive knowledge of personal capabilities indirectly influences the results of sensory evaluations. Future sensory and

consumer research should consider the significant role that these cognitive factors play in processing incoming chemosensory information (White et al., 2020).

Conclusion & Recommendations

Sensory evaluation is comprised of various techniques which have their own subset of methods that are widely used in various industries such as food and beverage, personal care, healthcare, and many other consumer products. This review focuses specifically on studies centered around health and wellness patients, products, and concepts, which also incorporate product efficacy to acceptability of sensory properties. The methods discussed in this literature review were discrimination testing (triangle test and paired-comparison test), descriptive analysis (consensus descriptive analysis and quantitative descriptive analysis), quantitative research (central location tests and home use tests), qualitative research (focus groups and one-on-one interviews) and emotion research (EsSense Profile®, MemVOC and emoSemio). The goal of this review was to show some of the methods available for sensory analysis and provide research examples around health and wellness. It is important to show that product acceptance and long-term success involves aspects beyond sensory attributes and the healthcare industry is a good example of this. It is always recommended to do additional research on more in-depth sensory methods since only a couple of the subsets of each method were included in this review. This review will be beneficial to stakeholders interested in sensory, health, and nutrition since it provides examples of how sensory analysis can be applied to the health and nutrition industry. This is to better understand new services and products which could increase their chances of success.

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Appendix A - Glossary of Terms

AAP	American Academy of Periodontology
CATA	choose all that apply
DBPCFC	double-blind placebo-controlled food challenge
EFP	European Federation of Periodontology
FP	Flavor Profile
HUT	Home use tests
IDIs	in-depth interviews
IDDSI	International Dysphagia Diet Standardization Initiative
MemVOC	Memories Vocabulary
NDD	National Dysphagia Diet
ONS	Oral Nutritional Supplements
QDA	Quantitative Descriptive Analysis
TFS	taxonomic free sorting
2-AFC	2-alternative forced choice