



Using implicit rather than explicit measures of emotions

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ABSTRACT

Implicit and explicit measures are typically combined in laboratory food studies. Results of these laboratory studies often show little additional value of implicit compared to explicit measures. We argue that implicit measures of food experience should not be regarded as a more expensive and more complex equivalent of established explicit measures. Instead, each type of measure provides complementary information. Whereas explicit measures capture especially the sensory aspects of the food itself, implicit measures capture especially the total food experience from pre- to post- consumption, which not only relates to the food itself but also to factors such as the physical and social context in which foods are consumed in real life. This requires that implicit measures are applied outside the conventional laboratory habitat. Fortunately, this becomes increasingly possible with current technical developments.

Why implicit measures? In contrast to explicit tests, implicit tests do not rely on consumers' conscious introspection, but use techniques that monitor nonconscious and often automated influences on consumer judgement, behavior and motivation. Fitzsimons et al. (2002) reviewed accumulating evidence for the enhanced role of nonconscious influences on consumer responses ranging from perception and memory to affect and choice. Dijksterhuis, Smith, and van Baaren (2005) further argued for the role of the unconscious in the routine behavior of consumers and proposed that much of it involves automatic goal pursuit. According to these authors, measures that rely on conscious and thorough information processing are unable to account for a large part of consumer choices, and in fact the vast majority of choices are "not the result of much information processing at all" (Dijksterhuis et al., 2005). Instead, they involve decisions that are contextually or environmentally cued-induced and either engage automatically activated attitudes or are completely devoid of deliberate attitude processing. In a complex consumption landscape largely determined by nonconscious influences, implicit measures would seem to be potentially useful tools for detecting consumers' "true" responses. So far, explicit measures have dominated studies in consumer and sensory research, but implicit measures are becoming more and more popular (Lagast, Gellynck, Schouteten, De Herdt, & De Steur, 2017).

What are implicit measures? The number of implicit measures is virtually limitless, but can be categorized into 1) measures that reflect

the activity of the central nervous system, such as EEG and MRI, 2) measures of activity of the autonomic nervous system such as skin conductance and heart rate, 3) expressive measures, such as facial expressions, and 4) behavioral measures, such as the speed with which food is sampled. Just like there is no single explicit measure that captures the full consumer's experience, there is neither one implicit measure that captures the full experience. Some implicit measures like EEG and MRI reflect brain activity, whereas other implicit measures, such as skin conductance and heart rate, reflect actions resulting from the brain activity. Other implicit measures such as facial expressions can for example serve to communicate experiences to others: expressions signaling happiness assure the fellow consumer that the food is safe and delicious and encourages the fellow consumer to join the meal. Yet other implicit measures reflect the combined effect of central and autonomic nervous system activity on behavior: a slight concern about the food's identity – and resulting doubts about the food's safety and palatability – may result in a more cautious sampling behavior. To complicate matters even further, implicit measures are not constant but vary over time. For example, heart rate responses may show a very fast deceleration (within hundreds of milliseconds) followed by a slower acceleration (over multiple seconds). The very fast changes typically reflect uncertainty about the food's identity, the so-called orienting response, whereas the slower responses reflect other aspects of the food.

Almost by definition, compared to explicit measures, implicit

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measures are difficult to measure and analyze, require specific expertise, are difficult to use in real-life situations, and are not very cost-effective in terms of required equipment (even though equipment becomes more and more affordable). Results of implicit measures should clearly add something to the results of explicit measures to justify the increased cost and complexity.

How do implicit measures compare with explicit measures?

Studies that combine implicit and explicit measures typically take place in the laboratory and with relatively simple foods and drinks, i.e., under standardized conditions that do not resemble real-life consumption situations. Under these conditions, the added value of implicit measures is sometimes difficult to identify. For example, in a laboratory study implicit and explicit responses to a number of commercially available breakfast drinks were compared. Explicit hedonic ratings showed few significant differences between the breakfast drinks. Implicit measures of autonomic nervous system (ANS) responses (heart rate frequencies, skin temperature, and skin conductance) did show more significant differences, but these differences were relatively small and difficult to interpret (see Fig. 1 for the ANS results) (De Wijk, He, Mensink, Verhoeven, & de Graaf, 2014). These results are in line with results from other studies. Samant, Chapko, and Seo (2017) failed to demonstrate large contributions of implicit ANS measures to the prediction of acceptance and preference for a number of taste solutions. Mojet et al. (2015) tested three different implicit measurement methods (face reading, emotive projection and autobiographical congruency) on their effectiveness in measuring the emotional effects of consumption of a number of commercial yoghurts and found that at least two of them were unsuccessful. Danner, Joechl, Duerrschmid, and Haindl (2014) measured skin conductance level, skin temperature, heart rate, pulse volume amplitude, facial expressions, as well as liking during and shortly after samples of commercial juices were tasted. The results showed that self-reported liking could not simply be explained by the measured ANS and implicit facial expression parameters. Kaneko et al. (2019) measured sip size, heart rate, skin conductance level, facial expressions, pupil diameter, EEG frontal alpha asymmetry, as well as valence and arousal for a set of well-liked commercial drinks and one disliked drink (vinegar) and found that the implicit measures discriminated between the liked and disliked drinks but not between the liked drinks.

Even though some of the lack of results may be caused by artefacts in the measurements (Mojet et al., 2015), these studies show that under tightly controlled laboratory conditions and with well-liked foods, implicit measures fail to demonstrate clear advantages over explicit measures.

Why should we not stick to explicit measures? If explicit testing in the sensory laboratory would be successful in the development of food products that do well in the marketplace, then there would be no reason to add relatively complex and expensive implicit tests to the repertoire. Unfortunately, this is not the case. Of the many new food products that reach the market place every year, the majority will not be successful and will disappear within one or two years from the marketplace even though most of these products have successfully passed numerous sensory and consumer tests prior to their market introduction. This suggests that the “standard” sensory and consumer tests, which typically include sensory analytical profiling, liking, and more recently emotion tests, have a low predictive validity with respect to commercial product performance. Possibly, consumer food choice outside the laboratory is less based on cognitive information processing and rational reasoning, and more on unarticulated/unconscious motives, emotions and associations. Reasons for likes or dislikes of specific foods are typically difficult to articulate but may determine much of our food choice. Unarticulated/unconscious motives, emotions and associations may not be captured very well by traditional explicit tests based on conscious cognitive processes and may better captured by other measures, for example measures that measure food-related responses implicitly rather than explicitly.

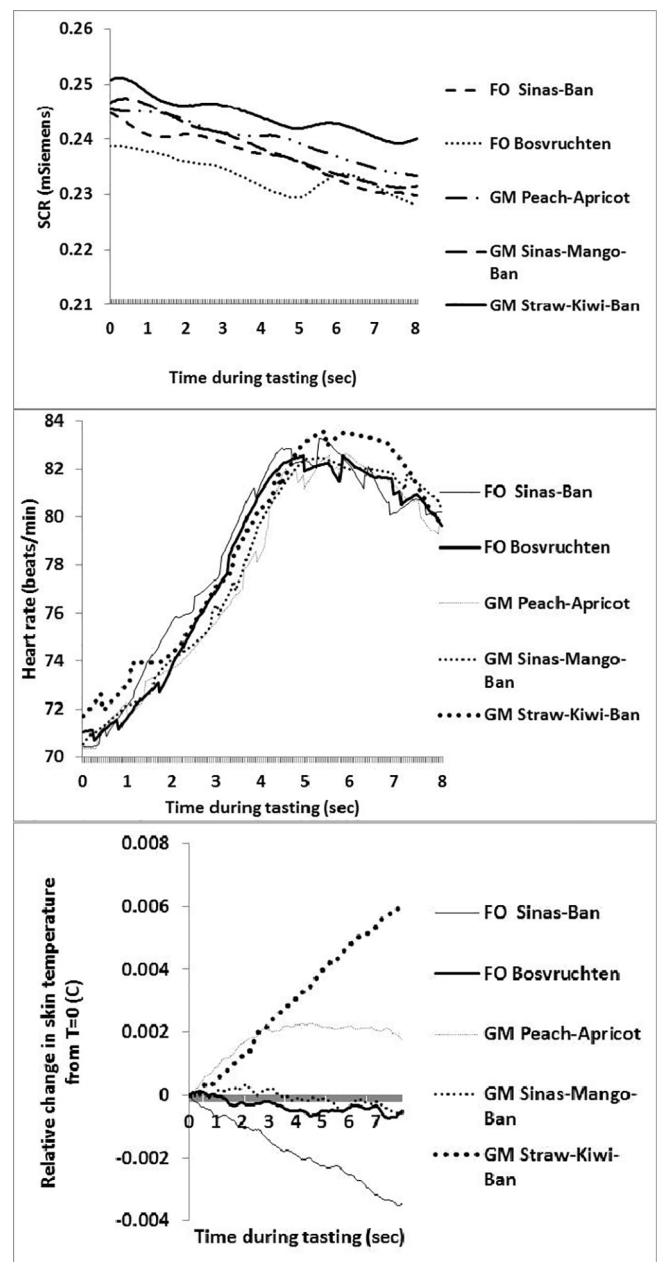


Fig. 1. Skin conductance responses (upper figure), heart rate frequency (middle figure) and change in skin temperature (bottom figure) during tasting of five commercial breakfast drinks. From: De Wijk et al. (2014).

We argue that real-life food experiences 1) are far more complex than food experiences measured in the laboratory, and 2) combine the results of conscious and unconscious processing.

The complexity of real-life food experiences. Food can be delicious when it is served in a nice restaurant on a beautiful plate, and in the company of close friends. The same food can be experienced differently when it is served on a plastic plate in a fast food restaurant in the presence of people that are not-so-close friends. When the food is not entirely in line with what is expected based on the description on the menu, or packaging, the experience will yet again be different. Finally, the experience can again be different when one was not very hungry at the start of the meal.

Bisogni et al. (2007) characterized seven dimensions of eating and drinking episodes: food & drink, time, activities, social setting, mental processes, physical condition and recurrence. Each of these dimensions may affect the way foods are experienced. This means that food

experiences reflect not only the perceived properties of the food, but also properties of the social and physical environment in which the food is consumed, and physical properties of the consumer (e.g. level of satiation).

Testing in real life. Eating and drinking in real-life situations outside the food laboratories has been primarily the domain of studies using explicit measures. The results often demonstrate effects of context on explicit hedonic and analytical food ratings. Numerous studies, starting with the ground-breaking studies from the US Army's Natick Laboratories (summarized by Hirsch, Kramer, & Meiselman, 2005), did find effects of test location on explicit measures (e.g., Weber, King, & Meiselman, 2004; King, Weber, Meiselman, & Lv, 2004, 2016; Delarue & Boutrolle, 2010; Boutrolle et al., 2005, 2007; Meiselman, Hirsch, & Popper, 1988, 2000). These studies typically compare ratings from the laboratory to ratings in real-life situations that differ along many of the dimensions mentioned by Bisogni et al. (2007) and others. Not only does this make identification of the contributions of each of these dimensions to explicit ratings virtually impossible, explicit ratings of liking and emotions may not be the best instruments to capture experiences that involve not only the food itself but also the broader context in which the food is consumed. All experiences are lumped together in hedonic and possible analytical scores making it difficult if not impossible to determine the effects of the food itself and those of all other possible factors. Separation of these effects may be especially important for the food industry in their quest to develop foods that are appreciated by consumers. In this sense, the current trend of testing foods in real-life situations offers a catch-22 situation: we know that food scores from the laboratory are reliable but not very relevant for real-life food appreciation because of its focus on the food rather than the food's interaction with the context. Unfortunately, by introducing the context in real-life testing it becomes difficult to isolate the effects of the food itself, which can be controlled by a food producer, from the effect of all other factors, which cannot or only to a certain extent be controlled by a food producer.

We will argue that 1) implicit measures may be more sensitive to the effects of each dimension, and that 2) implicit measures may be better suited to differentiate between the contributions of food- and non-food factors to the overall food experience. We provide support for these arguments with results of studies from our own and other labs.

Implicit tests more sensitive than explicit tests in real-life testing? Support for the increased sensitivity of implicit measures compared to explicit measures was provided by a study in which foods were tested repeatedly at two locations, the participants' own home and the laboratory, whereas all other aspects such as test procedures, social context, and time of day were kept constant (De Wijk et al., 2019). The

results showed virtually no effect of test location on explicit hedonic and sensory attributes. In contrast, implicit facial expressions and heart rate frequency measurements did show systematic effects: Compared to consumption in the laboratory, consumption at home was faster, triggered higher heart rates, and triggered more intense facial expressions of happiness, contempt, disgust and boredom (see Fig. 2 for the facial expression results).

Thus, the fact that participants were tested at home instead of the laboratory had clear effects on their physiological and behavioral responses to the test foods, without corresponding effects on their explicit hedonic and sensory judgements. It has to be kept in mind that in this study everything except for the location was kept constant, i.e. the same participants consumed the same foods at the same time using the same plates and utensils sitting alone in front of a webcam. The physical location of testing was the only dimension that was varied. It is under those circumstances that implicit measures proved to be more sensitive than explicit measures. Since then, we replicated this finding in another study in which the test location varied between a laboratory, a simulated grand café and an actual grand café (Zandstra, Kaneko, Dijksterhuis, Vennik, & de Wijk, 2020). Again, all other variables were kept constant, and the results of the explicit measures again showed no systematic effects of location. Other studies did demonstrate effects of variables such as location and plating on explicit measures. However, in these studies not only the physical context was varied, but other variables such as the social context and time of day were varied too. This makes it difficult to identify the specific variables that are responsible for the explicit effects.

There are various possible reasons for the higher sensitivity of implicit measures compared to explicit measures observed in the study described above. For example, explicit measures reflect by definition consumer experiences that are accessible via introspection, whereas implicit measures reflect also experiences that are inaccessible, for example because they are too fast to reach the consumer's consciousness. Another possible reason is that implicit measures may reflect processes that serve other functions than those reflected by explicit measures. Some implicit measures of autonomic nervous system responses are indicative for very basic reactions of fight and flight, i.e., they are meant to avoid harm to the consumer. In contrast, explicit responses typically reflect whether the consumer likes the food, or whether this food tastes sweeter than other foods. Moreover, most explicit measurements are rather static and reflect the end result of numerous mental processes, some of which are conscious, and others are unconscious. These mental processes are typically collapsed – or integrated – over time, resulting in one explicit score. To understand real-life food experiences, that reflect factors such as food, time, activities, social

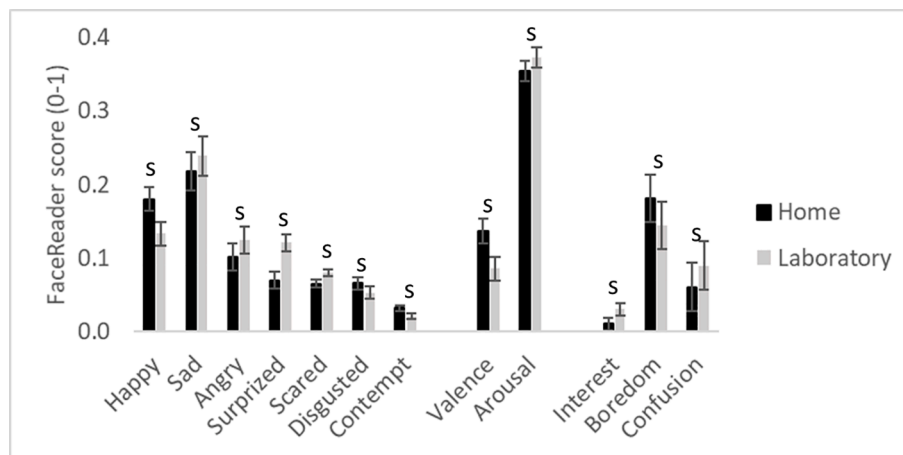


Fig. 2. Facial expressions to test foods consumed at home and in the laboratory. "S" indicate significant differences between locations at $p < 0.05$. From De Wijk et al. (2019).

setting, mental processes, physical condition and recurrence as well as their interactions, explicit scores may not be sensitive enough. In contrast, implicit measures are dynamic and represent a temporal window on processes, some of which are un- or subconscious and fast while others are conscious and slower. Moreover, different implicit measures reflect different types of conscious and unconscious reactions, some of which are fast whereas others are slow. The wide range of implicit measures and their ability to continuously monitor fast and slower reactions to food stimuli makes them well-suited to study the richness of food experiences.

Unraveling the complex real-food experiences: a theoretical framework. An overview for the various measures and their temporal effects is provided by appraisal theories of emotions such as the component process model (e.g., Coppin & Sanders, 2016, see Fig. 3). Appraisal theories assume that different stages of the temporal development of responses reflect different appraisals of stimuli, such as the stimulus' novelty, relevance or pleasantness. According to the component process model, an event's significance is evaluated on several criteria in a fixed temporal sequence. These appraisal criteria are: (1) Relevance (how relevant is this event for me), (2) Implication (what are the consequences of this event and how does it affect my well-being and goals), (3) Coping (how well can I adjust to these consequences), and (4) Normative significance (what does this event mean with respect to my self-concept and to social norms and values). Each criterion is associated with specific appraisals. For example, when a stimulus such as a food is encountered, the first and fastest appraisals concern the relevance of the stimulus for the consumer. These relevance appraisals include appraisals of the stimulus' novelty, its intrinsic pleasantness, and the relevance of the stimulus for the perceiver's goals. Each of these appraisals triggers specific physiological responses (action tendencies, motor expressions, and subjective feeling responses), each with its own specific function. Action tendency refers for example to whether the stimulus may be a threat that requires avoidance, whereas motor expressions serve to

communicate this possible threat to others via facial expressions. The relevance appraisal is followed by appraisal of the possible implications of the stimulus for the perceiver. These appraisals are different from the previous relevance appraisals, and will trigger a different set of reactions, and so on. Interestingly enough, appraisal theories such as the component process model do not exclude explicit measures in favor of implicit measures. In fact, explicit measures are also part of the model, as indicated by the explicit measures of "subjective feelings". These models see the results of the explicit measure of feelings as a reflection of the cumulative effect of the temporal events that consumers are aware of. This does not mean however that events that consumers are not aware of, either because they are too fast, and/or because they are not available for introspection, are not important for the food experience.

Appraisal theories such as the component process model discussed above assume a fixed temporal sequence in which the stimulus is evaluated on several criteria, whereby each criterium is associated with specific appraisals. The effects of each appraisal can be measured using various implicit and explicit techniques. Important is that these appraisals capture interactions of the "event", for example a specific food with intrinsic pleasantness/unpleasantness, with the consumer (e.g., is this food familiar to this consumer), and with the context (e.g., is the food's taste and texture in line with expectations raised by the packaging?).

Some examples of implicit measures. Implicit measures are still relatively new in food science, and are typically used in laboratory studies that do not resemble complex real-life situations. Hence, concrete evidence that implicit measures are especially useful in understanding real-life food experiences is virtually absent at this moment. However, we will provide some examples of implicit measures from laboratory studies that do relate to real-life phenomena such as the food's relevance, consumer expectations, branding, and physical location. These examples are from published and unpublished studies from our lab.

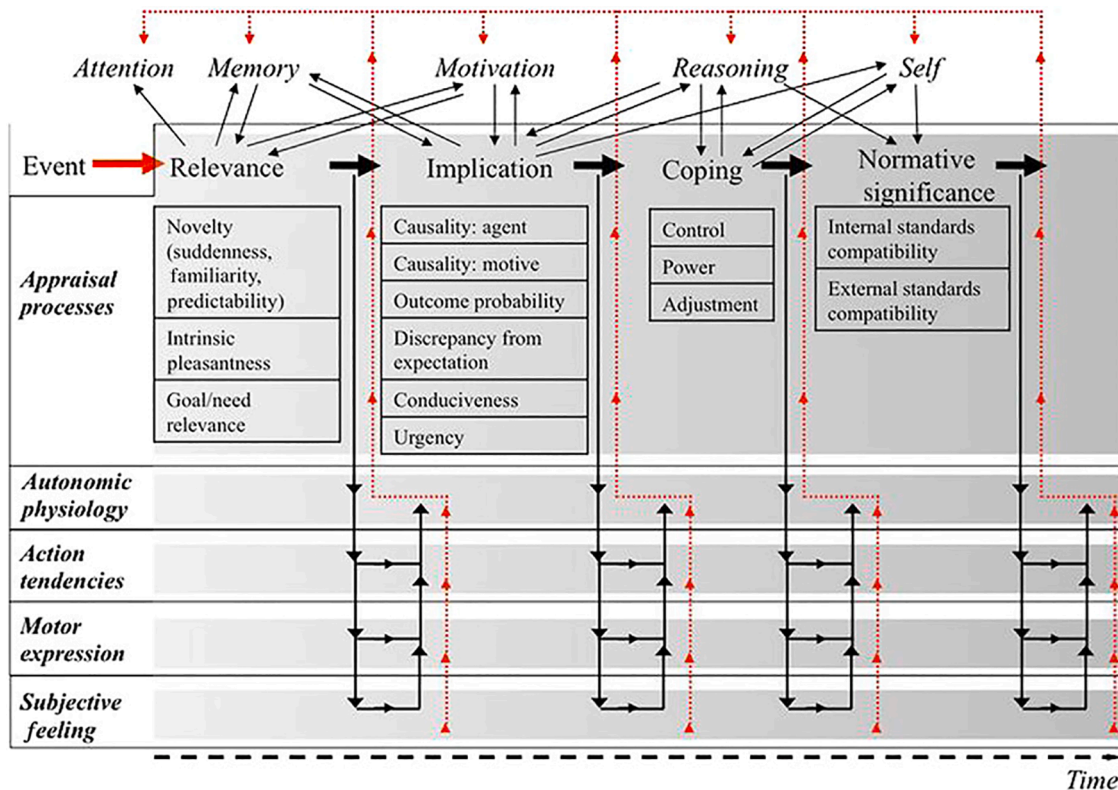


Fig. 3. Black arrows on top of the figure represent the effects of appraisal criteria on other cognitive processes (eg, attention, memory). Gray arrows represent the effects of different components (eg, autonomic physiology, action tendencies) on other cognitive processes. The different components are synchronized during an emotional episode, as shown by the black arrows on the bottom of the figure. (Figure and legend from Coppin & Sander in Emotion Measurement (ed. Meiselman).

Branding and expectations. Previously, results from De Wijk et al. (2014) from implicit and explicit measures of the taste of (unbranded) breakfast drinks were discussed. Those results suggested limited added value of implicit over explicit measures. In a follow-up of this study, a branded condition was added, i.e., prior to tasting subjects were presented with the package with brand name of the breakfast drink instead of an unbranded container with the breakfast drink. The effect of branding on explicit responses to the taste were relatively small. In contrast, the effect of branding on implicit responses was relatively large: the sight of the package with brand name significantly raised the heart rate frequency as well as skin conductance compared to the sight of the unbranded container with the breakfast drink. These effects continued during the subsequent tasting, even though the relative increase in heart rate during tasting was considerably lower in the branding condition (Fig. 4). These effects were largely independent of the specific brand and seem to reflect increased arousal induced by the branding information. The modulating effects of branding on heart rate responses during tasting may reflect taste expectations that are formed by the packaging and brand name. When these expectations were met, i.e., the taste corresponded with the brand shown previously, implicit responses were lowered.

However, when expectations were not met, i.e., the taste did not correspond with the brand shown previously, skin conductance measures were extreme compared to the unbranded condition (see Fig. 5). Combined, these results suggest that adding a context, in this case images of packages with brand name, heightens the subject's overall level of arousal and generates expectations that are either confirmed or disconfirmed during subsequent tasting.

Relevance of the food for the consumer. Expectations should only affect consumer's responses when the consequences are relevant, i.e., viewing the package with brand name becomes especially relevant when the subject knows that he/she has to taste the content of the package next. Otherwise, the image of the package has much less meaning. This was indeed shown in an earlier study (De Wijk, Kooijman, Verhoeven, Holthuysen, & de Graaf, 2012) where subjects were presented with images of liked and disliked foods, followed by an instruction to either

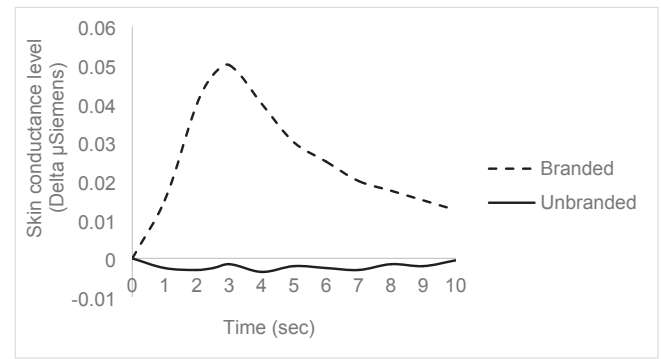


Fig. 5. Skin conductance responses when the taste of a breakfast drink did not match the previously viewed brand. Responses to the same taste in the unbranded condition are shown for comparison (de Wijk et al., unpublished results).

smell or taste the food, or to do nothing. The results showed that the implicit responses to the image of the food varied with the instruction of what to do next: responses were low when the image only needed to be visually inspected, and increased when the food was going to be smelled and tasted (see Fig. 6). Thus, implicit measures seem to capture the combination of the food hedonic properties and their relevance for the consumer.

Physical location. Implicit measures are not only sensitive to relatively small variations in context, such as the presence of a food image or food package but may also be sensitive to larger changes in the physical context as suggested by another study. In this study, subjects equipped with heart rate and skin conductance monitors rated food products that were displayed on shelves in a room regarding aspects such as health and sustainability. During these ratings, subtle changes in the ambient conditions of the test room were implemented. These changes related to ambient aromas, ambient sound, and ambient lighting. While most subjects were not even consciously aware of these changes in the

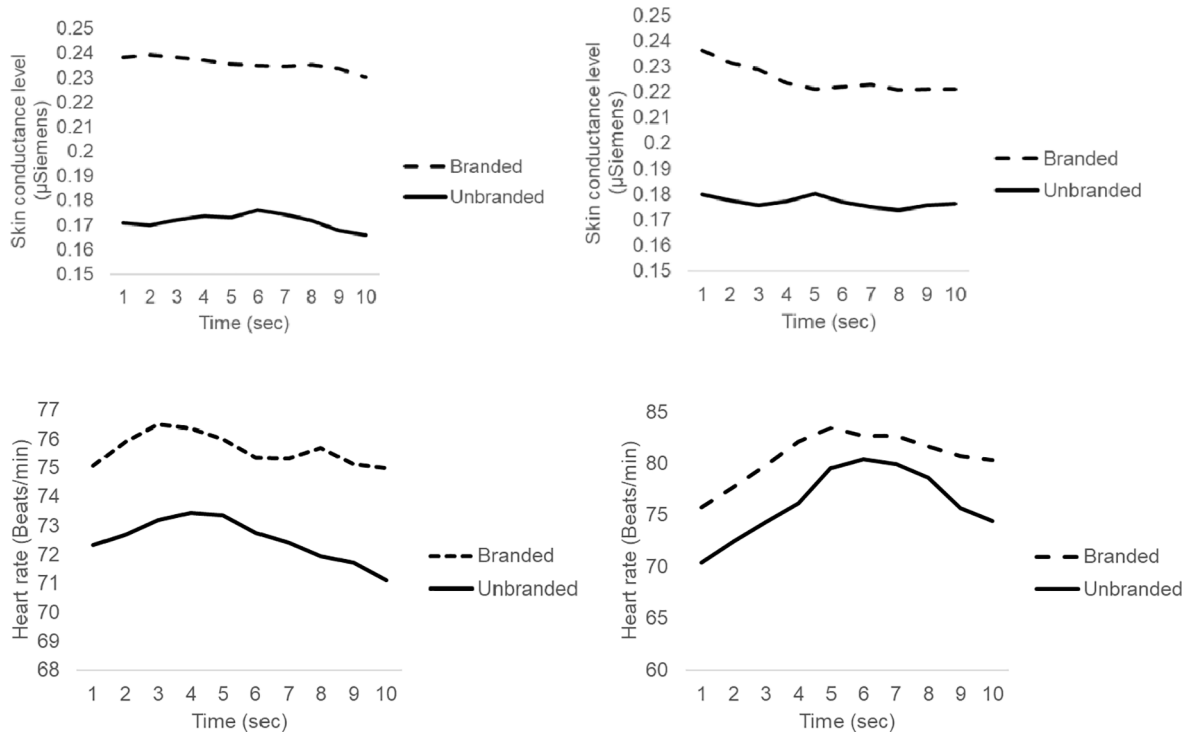


Fig. 4. Skin conductance levels (upper figures) and heart rate frequencies (lower figures) to the sight (left figures) and taste (right figures) of unbranded and branded breakfast drinks. (de Wijk et al., unpublished results).

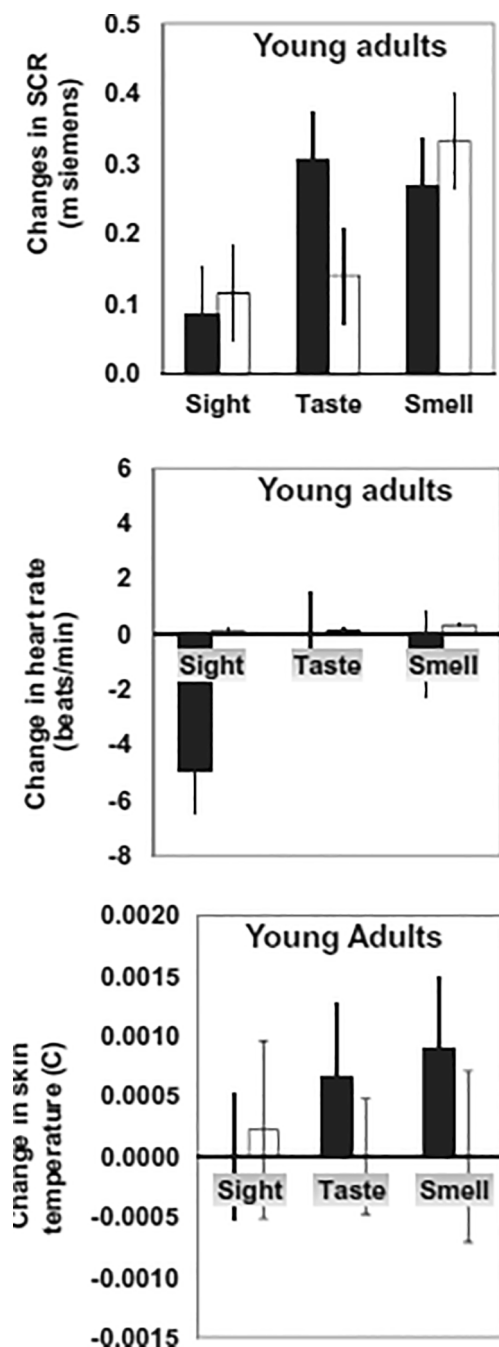


Fig. 6. changes in skin conductance response (upper figure), heart rate frequency (middle figure) and skin temperature when participants or instructed to either view, or view & taste, or view and smell either liked (black bars) and disliked foods (white bars) From De Wijk et al., 2012).

ambience, their implicit physiological measures showed considerable variations (see Fig. 7). Possibly, these variations reflect differences in something that we may call “well-being”, a term that is frequently used but that lacks a proper definition and operationalization. Yet, “well-being” may be a very relevant factor in the effects of ambience on food experiences described earlier. Similar to food experiences, the sense of well-being may be difficult to capture with explicit measures because various aspects of well-being may not be readily accessible for introspection. And again, implicit measures may offer a promising alternative.

Local ambient sound, aroma and lighting conditions were also varied in a real-life supermarket and their effects on consumer behavior and

sales were monitored over several weeks (De Wijk, Maaskant, Kremer, Holthuysen, & Stijnen, 2018). The results showed that ambient conditions affected consumer behavior (speed of movement in front of shelves) but not sales.

Taken together, we argue that implicit measures in food sciences have limited added value in traditional sensory food tests that take place in the laboratory. These tests typically focus on the food’s sensory properties and factors such as context, expectations, and relevance are seen as unwanted because they interfere with the subject/consumer’s ability to focus on the properties of the food itself. However, these factors play an important role in our real-life food experiences even though we are often unaware of them because most food-related decisions are made unconsciously. Implicit measures may play an important role in understanding the way these factors contribute to our real-life food experiences.

The challenge: using implicit measures in real-life studies. Real-life consumption situations such as supermarkets and restaurants are not yet the natural habitat of implicit measures because they typically require a high degree of control over the food stimulus, the consumer and the situation, all of which are lacking in real-life situations. However, we believe that current technological developments will facilitate the use of implicit measures in real-life situations. The first development is the miniaturization of sensors and devices for heart rate, skin conductance, eye tracking and EEG which makes them better suited for real-life applications. These techniques can be combined with video recordings of the face allowing for the simultaneous recording of facial expressions and even implicit measures such as heart rate. Software developments will facilitate analyses of the results for example by automatically linking the responses of the consumer to the location of the consumer in the food environment (e.g. location in the supermarket). Another promising technical development is the use of virtual reality that allows consumers to be exposed to food environments via VR glasses while they are sitting in the laboratory. This would combine the increased control of the laboratory with the increased relevance of a real-life situation. Yet another promising development is the so-called immersive technologies where real-life consumption situations are recreated in the laboratory using combinations of image projectors, sound systems and sometimes even odor dispensers (Bangcuayo, Smith, Zumach, Pierce, & Guttman, 2015; Holthuysen, Vrijhof, De Wijk, & Kremer, 2017; Delarue, Brassat, Jarrot, & Abiven, 2019; Hannum, Forzley, Popper, & Simons, 2019; Zandstra et al., 2020). The result is a simulated situation with the look and feel of the real situation, but with the added benefits of the increased control associated with a laboratory.

Implicit measures cannot only be used for specific studies carried out in specific contexts (either real-life or VR) but could in principle also be used for 24/7 monitoring of consumer’s experiences. Mobile devices and wearable sensors have become so powerful and non-intrusive that the combination of a smartwatch (as a body-worn sensor) and a smartphone (as a communication and display device) offers a wealth of new possibilities for continuous measurement of implicit and explicit responses to food and drinks. Several models are available nowadays that offer heart rate and heart rate variability (through photo plethysmography), galvanic skin conductance, skin temperature, activity (through 3D accelerometer and gyroscope), and a battery life exceeding 24 h. In a study with continuous data collection through a wearable sensor and a smartphone, and more than 1000 participants, Smets et al. (2018) were able to establish distinct “digital phenotypes” related to stress. For personalized feedback and to capture consumer experience in real-time, a programmable display, response buttons and the possibility to extend the firmware with new algorithms is desirable. This is still a rare feature among commercially available study watches. Increasing functionality and ongoing cost reduction of wearable sensors, such as research-grade smartwatches, will stimulate widespread adoption of these tools for implicit measurement of emotions by the consumer science community.

What will future food experience studies look like? A three-week trial could include 24/7 measurement of basic activity and physiological

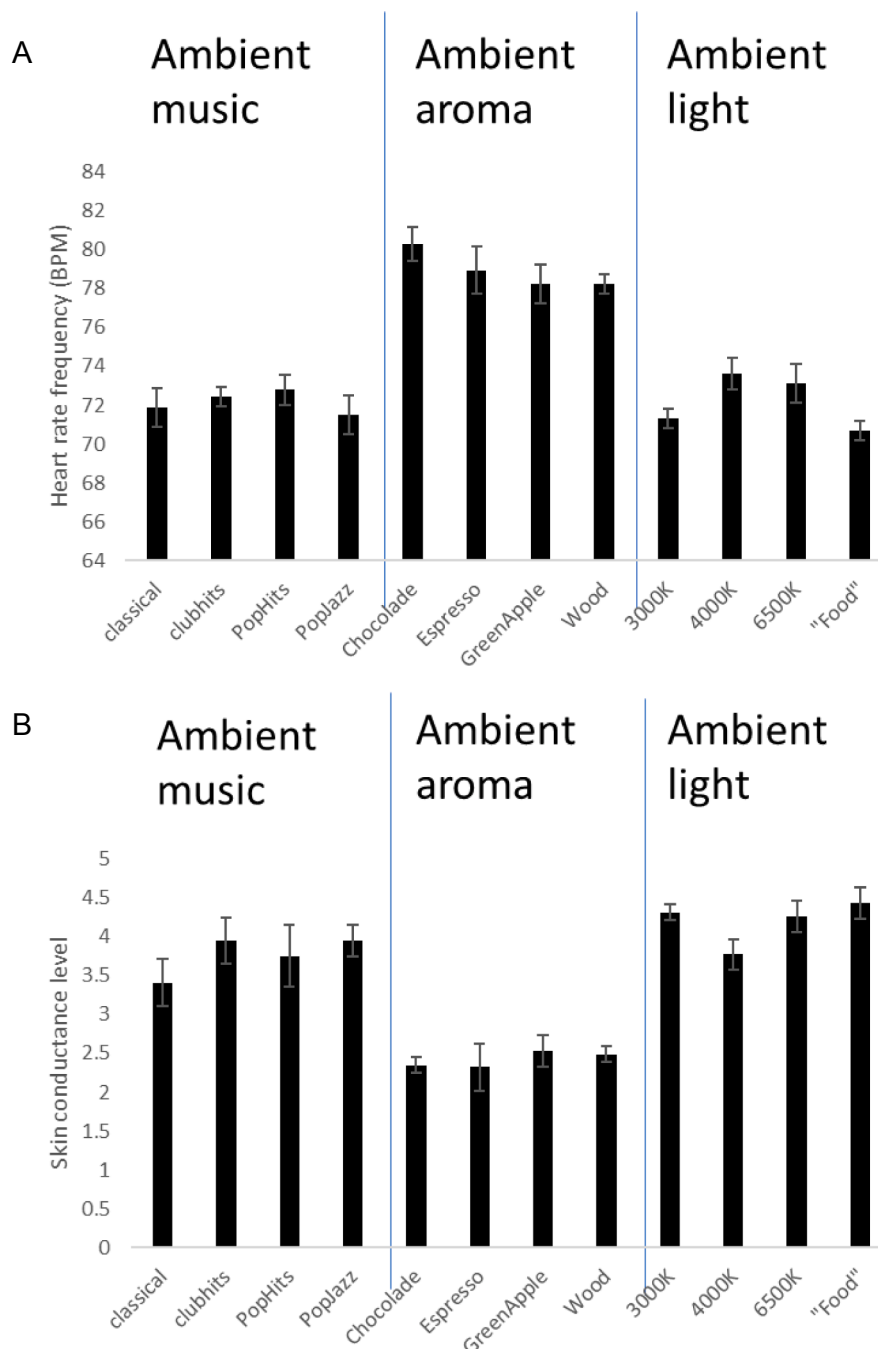


Fig. 7. Averaged heart rate frequency (A) and skin conductance (B) during a 15 min stay in a room with varying ambient music, aromas and lighting conditions (from de Wijk et al., unpublished results).

parameters via the smartwatch, while the smartphone prompts the subject to fill in a short questionnaire during each meal, while his/her facial expression is captured via the phone camera. Data from smartwatch and smartphone are then stored in a single, secure time-series database for integrated analysis. This perspective is appealing for researchers, because the wrist-worn watches allow for continuous, scalable, unobtrusive, and ecologically valid data collection of behavioral and physiological data.

In conclusion, we argue that implicit measures of food experience should not be regarded as a more expensive and more complex substitute of established explicit measures. Instead, each type of measure provides complementary information. Whereas explicit measures capture especially the sensory aspects of the food itself, implicit measures

capture especially the total food experience from pre- to post-consumption, which not only relates to the food itself but also to factors such as the physical and social context in which foods are consumed in real life. This requires that implicit measures are applied outside the conventional laboratory habitat. Fortunately, this becomes increasingly possible with current technical developments.

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