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Facial expressions and autonomous nervous system responses elicited by tasting different juices

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ABSTRACT

The aim of this study was to get a better understanding of reactions elicited by the taste of foods using the example of different juices. The reactions investigated were the rating behavior of self-reported spontaneous liking, various autonomous nervous system (ANS) responses and implicit as well as explicit facial expressions. Therefore, the following four hypotheses were tested: 1) Different sensory stimuli of juices elicit different ANS responses. 2) Differences in facial expressions elicited by sensory stimuli of juices used in an implicit and explicit measurement approach can be detected by using FaceReader 5. 3) Self-reported liking is correlated with the measured ANS parameters and the elicited facial expressions. 4) The measured ANS parameters, facial expressions and self-reported liking allow identical differentiations between samples.

Skin conductance level (SCL), skin temperature (ST), heart rate (HR), pulse volume amplitude (PVA) and the facial expressions of 81 participants were analyzed during and shortly after tasting juice samples (implicit measurement approach). Additionally, participants were asked to show how much they liked the tasted sample with an intentional facial expression (explicit measurement approach). Banana, grapefruit, mixed vegetable, orange and sauerkraut juices were used as sensory stimuli.

The juices elicited significant differences in SCL and PVA responses and intensities of several facial expressions. For these parameters a moderate correlation with self-reported liking was found, allowing a differentiation between liked, disliked and neutral rated samples. The results show that self-reported liking cannot simply be explained by the measured ANS and implicit facial expression parameters, instead providing different information. Significant differences in facial expressions between the implicit and explicit approach were observed. In the implicit approach participants showed hardly any positive emotions when tasting samples they liked, whereas in the explicit approach they displayed a high degree of positive emotions. In both cases negative emotions were shown more intensely for disliked samples.

1. Introduction

Since its inception, sensory and consumer science has mainly focused on methods based on self-report to characterize perceptions and the food samples that elicit these perceptions. To study further aspects in the control chain of nutritional behavior – besides perceptions – such as emotions, expectations and memories, introspective methods have been developed and applied in the last ten years (Adriaanse, de Ridder, & Evers, 2011; Arnow, Kenardy, & Agras, 1995; King & Meiselman, 2010). Yet, all these introspective methods suffer from the fundamental problem of conscious and rational processing to be able to answer the questions, consequently biasing the results (Koster, 2003).

Therefore, implicit physiological and behavioral measurements are in development to get a more complete and deeper understanding of consumers' reactions towards culinary stimuli (Köster, 2009). De Houwer and Moors (2007) defined an implicit measure as "a measurement outcome that reflects the to-be-measured construct by virtue of processes that have the features of automatic processes", which are characterized as "unconscious, unintentional, uncontrollable, effortless and fast". Investigating these reactions might considerably contribute to the understanding of consumers' nutritional behavior (Canetti, Bachar, & Berry, 2002; Garcia-Burgos & Zamora, 2013).

1.1. Measuring autonomous nervous system reactions

As a part of the peripheral nervous system, the autonomic nervous system (ANS) acts as a control system, functioning largely below the level of consciousness. Autonomic control of several organs aims to maintain homoeostasis in health (Dorland, 2011). The measured physiological parameters skin conductance, heart rate, pulse volume and skin temperature are to a high extend under control of the autonomous nervous system. They are often related to stress, arousal and emotions (Kreibig, 2010). General arousal leads to an increase of sympathetic-driven

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responses of the autonomous nervous system, i.e. increased heart rate, blood pressure and tonic electrodermal activity (Boucsein & Backs, 2008).

Many studies investigated ANS parameters in the context of stress situations, psychological disorders like anxiety or schizophrenia, but only a few focused on ANS reactions in the context of food. Most of the studies focusing on food used pictures (Drobes et al., 2001; Overduin, Jansen, & Eilkes, 1997) or olfactory food stimuli (Alaoui-Ismaïli, Vernet-Maury, Dittmar, Delhomme, & Chanel, 1997; Robin, Alaoui-Ismaïli, Dittmar, & Vernet-Maury, 1998, 1999), but only a few studies examined the actual tasting situation (Nederkoorn, Smulders, & Jansen, 2000; Rousmans, Robin, Dittmar, & Vernet-Maury, 2000).

Among ANS measurements, tonic electrodermal activity (EDA) parameters have been used as an indicator for arousal in psychophysiological research for a long time. EDA describes changes in the skin's ability to conduct electricity. It is also known as the galvanic skin response, which is the combination of the changes in the galvanic skin resistance and galvanic skin potential, reflecting the eccrine sweat gland activity, especially those on the palms and soles of the feet, which are involved in emotion-evoked sweating (Dawson, Schell, & Filion, 2000). It is regarded as a sensitive and valid indicator for the lower arousal range and reflects small variations in arousal state. Heart rate (HR; number of heartbeats per unit of time) is suggested to be an indicator for the higher arousal range and for somatically determined arousal processes (Epstein, Boudreau, & Kling, 1975; Miezejeski, 1978). Rousmans et al. (2000) stated that skin resistance and cardiac responses were the most relevant ANS parameters to distinguish among different taste solutions and that these differences could be associated with the hedonic valence. Pleasant tastes induced the weakest ANS responses, whereas the unpleasant ones induced stronger ANS responses. This also matches the findings of De Wijk, Kooijman, Verhoeven, Holthuysen, and de Graaf (2012). Evidence was found by Delplanque et al. (2009) for the temporal priority of stimulus novelty processing over pleasantness processing on cardiac activity. Nederkoorn, Smulders, Havermans, and Jansen (2004) showed that pulse volume amplitude (PVA, as a measure for changes in blood volume in arteries and capillaries) is related to the urge to eat favorable food. De Wijk et al. (2012) demonstrated that skin temperature was higher for liked foods than for disliked foods irrespective of age group, whereas Rousmans et al. (2000) found the opposite effect in an earlier work.

1.2. Measuring emotions

Many scientists, among them Charles Darwin (1872), have investigated the linkage between facial expressions and emotions. Facial expressions have been studied as indicators for emotional states and tools for communicating emotions. A very influential work in this field has been published by Ekman and Friesen (1971), linking basic emotions and facial expressions. In a later work, they introduced the Facial Action Coding System (FACS) (Ekman & Friesen, 1977) as a method to visually encode facial muscle movements. Due to the nature of this method, analyses are very time-consuming, specially trained coders are needed and real time detection of emotions is not possible, whereas automated facial recognition systems have the advantage of being faster and easier to apply. Some novel methods using self-reports of emotional states like EsSense Profile™ (King & Meiselman, 2010) or visual self-reports like PrEmo (SusaGroup BV, Nijbroek, The Netherlands) are quick to apply and user friendly, but have two major limitations, namely "cognitively biased" and to some degree retrospective.

Non-intrusive and fast ways to measure facial expressions are automated facial expression recognition systems like nViso (nViso SA, Lausanne, Switzerland), Affdex (Affectiva Inc., Waltham, USA) and FaceReader (Noldus Information Technology, Wageningen, The Netherlands). These methods are not as sensitive as electromyography (EMG) and highly reliant on good quality video recordings of the observed face. They are sensitive to anything that partially obstructs the view of the face, like haircuts with fringes or thick-rimmed/reflective glasses. Suboptimal lighting and camera angles might lead to misinterpretations of the emotional state of the face, at least for the level of technology at the time of this writing. However, the large improvements of these programs over the past few years, combined with more affordable computing power for real-time analysis or higher throughput in batch analysis, make these methods increasingly interesting. For this study FaceReader 5 (Noldus Information Technology, Wageningen, The Netherlands) was used.

It has been discussed that rating perceptions on a scale requires significant cognitive processing resulting in cognitive and scaling biases (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003; Schwarz & Sudman, 1996). To reduce these biases it might be a promising strategy to use explicit, intentional facial expressions. Despite the intentionality they are a very intuitive means of communication in everyday life, which human beings start using early after birth (Boyatzis & Satyaprasad, 1994; Josephs, 1994; Schmidt & Cohn, 2001). Facial expressions are permanently used intentionally as well as unintentionally in human interactions to convey valence information rapidly (Blair, 2003). Using the intuitive means of showing intentional facial expressions might make it easier for test persons to communicate the nature and intensity of their hedonic perceptions, at least easier than using rationale scales with numbers or lines on paper with pens or on a computer using input devices.

To our knowledge, there is only one study by De Wijk et al. (2012) investigating the combination of the analysis of facial expressions and ANS responses in a food context. In De Wijk's study the effects on facial expressions and ANS responses elicited by the first look at a product and by different instructions to look at, smell or taste liked as well as disliked samples were investigated.

Our study not only examined the effects of the actual tasting of food samples on facial reactions and selected ANS responses for the first time, but also highlighted their correlations to self-reported liking ratings. Previous studies examining the correlation between ANS parameters, facial expressions and self-reported liking showed moderate correlations (Alaoui-Ismaïli et al., 1997; De Wijk et al., 2012; Wendin, Allesen-Holm, & Bredie, 2011) indicating that these parameters deliver different information to a certain extent.

The first research question was to investigate whether juice samples are able to elicit significantly different ANS responses and facial reactions. The second question was whether these parameters are able to differentiate samples rated as liked, disliked and neutral rated samples. Liquid products were chosen as stimuli, because chewing and eating movements would potentially disturb the measurement of facial expressions. Additionally, the use of liquids made our results comparable to previous studies (Danner, Sidorkina, Joechl, & Duerrschmid, 2014; Wendin et al., 2011; Zeinstra, Koelen, Colindres, Kok, & de Graaf, 2009). By using juice samples available on the market we wanted to have a broad spectrum of tastes easily distinguishable for the consumers and significantly varying in liking, therefore allowing a good comparison between liked and disliked samples. After a preliminary test with 41 participants tasting a wide range of different juices sold in Austrian supermarkets, five juice samples that fulfill these requirements best and showing similar familiarity ratings were selected for this study.

To answer the research questions, the following four hypotheses were tested:

H1. Different sensory stimuli of juices elicit different ANS responses.

H2. Differences in facial expressions elicited by sensory stimuli of juices used in an implicit and explicit measurement approach can be detected by using FaceReader 5.

Furthermore, differences between implicit and explicit measurements of facial expressions were investigated.