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Short Communication

Increasing saltiness perception through perceptual constancy created by expectation

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ABSTRACT

Reducing salt levels in food products is an important motivation for research, as the general intake of salt by consumers is too high. Finding strategies for salt reduction, while maintaining salty taste of products remains a big challenge. In this paper we show the effect that a perceptual expectation of a taste can have on subsequent taste perception, in the same product. A perceptual expectation is based on previous experience, memory, or other information from the product. Our hypothesis is that, if a product looks the same, smells the same and has the same texture as the product one is used to eat, small variations in taste will go unnoticed. In a consumer study, we investigated if the expectation, or implicit assumption, that saltiness remains constant across mouthfuls, can indeed reduce the perception of variation in salt concentration. We were able to demonstrate the existence of such an effect. We found that perceptual expectation, based on the first bite, can influence saltiness perception.

1. Introduction

Currently, consumers have too high salt intakes, resulting in an increased risk of stroke and cardiovascular disease (World Health Organisation, 2007). Furthermore, it has been demonstrated that significantly reduced sodium intake is an effective method to lower hypertension and associated risks on cardiovascular disease (Sacks et al., 2001). The World Action on Salt and Health Organisation (WASH) states that reduction of salt intake from (current average) 9–12 g/day to 5–6 g/day will have a major effect on public health. Thus, reducing salt levels in food will likely deliver a health benefit to consumers. Current salt intake is mainly due to "hidden salt" in processed foods (Hermansen, 2000; Liem, Miremadi, & Keast, 2011). Therefore, one of the priorities for food companies is to establish salt reduction in their total food portfolio. Hence, there is a need for methods that enable salt reduction in products while maintaining the same consumer acceptance of the products. The study reported here was conducted in order to investigate the impact of expectations on saltiness perception. By perceptual expectation, we mean the expectation one has about how a product would taste (feel, smell, etc.), based on previous experiences with same or similar products.

When a product is consumed, many variables will affect its taste perception, such as mastication rate (Boland, Delahunty, & van Ruth, 2006), ingredient interactions (Plug & Haring, 1994) and taste adaptation (Gillan, 1984), yet this variation often remains unnoticed in the overall flavour perception (Theunissen, Polet, Kroeze, & Schifferstein, 2000). According to Huttenlocher, Hedges, and Vevea (2000, p. 221), "people use prior information in estimating stimulus values that are represented inexactly", pointing at a top down effect of expectation. Flavour or taste expectations can arise from different sources. For example, Pangborn, Berg, and Hansen (1963) showed the impact of expectations based on visual information (the colour of dry white wine) on taste perception. They found that dry white wine coloured pink was reported to taste sweeter than the same, not coloured, white wine. Similar expectation driven outcomes were shown with different products, for different modalities (*e.g.* de Wijk, Polet, Engelen, van Doorn, & Prinz, 2004; Duncker, 1939; Levitan, Zampini, Li, & Spence, 2008; Zampini, Sanabria, Phillips, & Spence, 2007).

Mechanisms explaining how expectation can modulate flavour perception are just beginning to be understood. Some predictions can be made from the assimilation-contrast model which proposes that, when a food product is sufficiently similar to past consumption, it 'meets expectations' and may be assimilated towards the norm (Woodruff, Cadotte, & Jenkins, 1983). In line with the above, the assimilation-contrast model also predicts that flavour is repulsed away from the norm ('contrast') when the consumer perceives a discrepancy between what was tasted and what was remembered.

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Woods, Poliakoff, Lloyd, Dijksterhuis, and Thomas (2010) demonstrated that certain drink stimuli, of different sweetnesses when tasted in isolation, can taste identical to each other under special circumstances. In their study pairs of drinks seen to be poured from the same jug were reported more similar than pairs of drinks seen to be poured from different-jugs. These authors also demonstrated that an assimilation effect occurred within a certain taste intensity window only, outside such a window the effect subsided. In another study Woods et al. (2011) showed that a created expectation, by means of information provided, has an effect on subsequent (sweet) taste perception. They publish both psychophysical and neuro scientific evidence for this. These studies point at the importance of top down effects, as expectations, for taste perception.

Here, we investigate whether we can use an expectation, based on subjects' implicit assumption that taste remains consistent across mouthfuls, to reduce the perception of variation in saltiness, within one product. Thus, our first hypothesis is that perceptual expectation built from past experience with a similar product, can "smooth" out taste variability within one product. To test this hypothesis, heterogeneous sandwiches, with a spread-product, containing regions made with different concentrations of salt were compared with homogeneous sandwiches, containing the same overall salt content in the spread distributed homogeneously throughout the product. The heterogeneous sandwiches were made in such a way that each mouthful contained a different homogeneously distributed level of salt.

Our second hypothesis is that perceptual expectation is mostly based on the first bite taken from a product. Indeed, we suggest that if the product looks homogeneous, and thus, that taste constancy is expected, the first bite "anchors" the taste intensity for the overall product, hiding variability in the rest of the product. Sandwiches with a different salt concentration in the first bite were compared with sandwiches that had a homogeneous distribution of the same salt content. This set-up allowed us to explore further, in a "real product" context, and for salt taste, the perceptual expectation demonstrated earlier by Woods et al. (2010).

In the current study we do not introduce a specific expectation in order to create its confirmation or dis-confirmation, nor do we focus on acceptability (as in Cardello & Sawyer, 1992). We pose that the 'expectation' in our study acts as a subtle top down effect that can affect subsequent intensity perception of salt stimulation.

This work is different from other studies with heterogeneous distribution of tastants, where effects found are due to the heterogeneous stimulation of receptors (cf. Busch, Yong, & Goh, 2013), or pulsatile stimulation in gustometric studies (cf. Busch, Tournier, Knoop, Kooyman, & Smit, 2009). Such stimulation is believed to counter adaptation and increase saltiness. Heterogeneous stimulation is often studied within single bites. In our study the effect works between bites. We show the first bite to have an effect on subsequent bites.

2. Materials and methods

2.1. Participants

The consumer panel used in this study consisted of 198 consumers (99 males, mean age 43), recruited in Cologne (Germany), who regularly (at least once in the past month) consume savoury sandwiches. They were naïve regarding the tasting procedure and not aware of the test objective. Individuals who took part in this study were in good general health. Pregnant or breast feeding women, women planning to become pregnant, anyone who had blood pressure issues and people who had or suspected an allergy to food were excluded. Specifically, anyone who had an allergy to bread, cheese and/or any dairy product was excluded.

2.2. Stimuli

Sandwiches were made of white bread (Golden Toast, American Sandwich, 1.67% salt w/w) and a cream cheese spread product (Brunch Légère, 0.4% salt w/w). In total four different sandwiches (named A–D in Fig. 1) containing the same amount of cream cheese and the same *average* total amount of salt (0.33%) on top of the salt that was present in the bread and the cream cheese, were designed. The sandwiches differed in the way the salt is distributed in the sandwich. The general design for the sandwiches is shown in Fig. 1. Sandwiches were made consisting of three different parts, each part corresponding to the size of a single bite. Salt was added to the cream cheese product, according to the percentages shown in Fig. 1. The salt added was normal table salt, it was mixed through the brunch spread, no crystals could be detected after mixing. The 1.67% salt in the bread and the 0.4% salt in the cream cheese base remained constant in each sandwich. As the consumers were instructed to eat the product in three bites, each bite was homogeneous in terms of salt content.

The size of each sandwich was (8 × 2 × 2) cm and the weight of cream cheese spread per sandwich was 4.5 g (3 parts × 1.5 g of spread per part). All sandwiches were similar visually (see Fig. 2).

2.3. Procedure

The task of the consumers consisted of a forced-choice 2-AFC procedure, which requires them to compare the homogeneous sandwich A with each of the heterogeneous sandwiches (B–D, see Fig. 1) in a set of pair wise presentations. Participants received the two samples in a pair, which they had to consume in an indicated order and direction. They were asked, for each sandwich, to eat them in three equal bites and to swallow after each bite. Each sandwich had to be eaten in full (up to the crust, see Fig. 2). The task consisted in indicating, for each pair, which of the two sandwiches they perceived as being the most salty. Between the two sandwiches in a pair, participants were asked to rinse their mouth with (lukewarm) water.

Between the pairs, a break of 5 min was given, during which participants were asked to rinse their mouth thoroughly with (lukewarm) water. During that break, the next pair of sandwiches was freshly prepared as the sandwiches needed to be prepared as fresh as possible to prevent the sandwiches from getting soggy or dry and to minimise any potential migration of the salt. The task

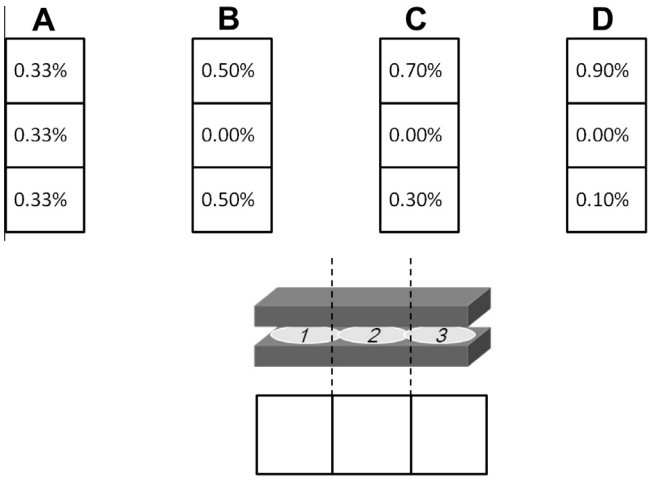

Fig. 1. Schematic representation of the four (8 × 2 × 2) cm different sandwiches (A–D) used in the study (top). Each sandwich consists of three different regions (1–3; bottom). The % in the figure indicates the levels of salt added to the cream cheese spread, on top of the constant level of salt in the bread and the cream cheese base.