Food Quality and Preference 99 (2022) 104572

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

A preliminary investigation on the effect of immersive consumption contexts on food-evoked emotions using facial expressions and subjective ratings

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ARTICLE INFO

Keywords:
Consumption context
Immersive technology
Food-Context congruency
Food
Liking
Facial expressions
Self-reported food-evoked emotions
Repeated exposure

ABSTRACT

Previous studies have investigated effects of consumption contexts on food experiences using actual real-life contexts and recreated immersive contexts. The results typically show that food is experienced differently depending on the context. It is not clear whether context effects on food experiences are independent of the effects of specific foods. E.g., are all foods experienced more positive in a nice sushi restaurant or only the foods that have strong associations (congruent) with this context, such as sushi? A previous study with recreated beach and sushi restaurant contexts, demonstrated no effect of congruency on liking of the tasted foods. To verify whether the lack of congruency effects was caused by the relatively insensitivity of explicit response measures such as liking, implicit (facial expressions) and explicit (scores) measures of food-evoked and general emotions were used in the same study and those results are reported here.

Thirty-five participants were exposed repeatedly in seven sessions in one of two recreated contexts (sushi restaurant and beach) to foods that were either congruent (sushi in the sushi restaurant, popsicle at the beach, and iced tea) or incongruent (sushi at the beach and popsicle in the sushi restaurant) with the recreated context. Contexts were switched in an eighth and final session. Facial expressions and self-reported food-evoked emotions showed significant effects of context and foods ($p < 0.05$). General and food-evoked self-reported emotions were closely related, and showed systematic changes over repeated exposure, immersive context and food. No effect of food-context congruency was found, i.e., effects of contexts and foods on self-reported food-evoked emotions and facial expressions were independent. Food-evoked emotions were more positively valenced in the beach context compared to the restaurant context irrespective of foods ($p < 0.05$). After repeated exposure, self-reported emotions of boredom were intensified and those of interest were reduced, irrespective of food and context. A subsequent switch to a different context did not produce additional effects on emotions. Facial expressions also varied independently with food and context but were not affected by repeated exposure and were affected by the switch to a different context.

In conclusion, the results show that 1) physical and social consumption contexts that are recreated in the laboratory affect general and food-evoked emotions measured by self-reported emotions and facial expressions, 2) foods and contexts affect food-evoked self-reported emotions and facial expressions independently , and 3) results of self-reported food-evoked emotions and facial expressions showed similarities but also differences pointing to the added value of measuring facial expressions.

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https://doi.org/10.1016/j.foodqual.2022.104572
Received 21 June 2021; Received in revised form 5 February 2022; Accepted 22 February 2022
Available online 24 February 2022

1. Introduction

Food products are seldomly consumed in isolation. Instead, foods are typically consumed in specific consumption situations such as at home, in a restaurant or a canteen. These situations tend to shape our food experiences. A food consumed in one situation may taste different than the same food tasted in a different situation. Consequently, food experiences measured in for example a sensory laboratory may be different from experiences for the same foods measured in a real-life situation. Indeed, several studies reported higher preference ratings for foods consumed in real-life situations (e.g. Boutrolle, Arranz, Rogeaux, & Delarue, 2005; De Graaf, Cardello, Kramer, Lesher, Meiselman, & Schutz, 2005; Hersleth, Mevik, Naes, & Guinard, 2003; Holthuysen, Vrijhof, De Wijk, & Kremer, 2017; King, Meiselman, Hottenstein, Work, & Cronk, 2007) even though these effects are not univocal as demonstrated by other studies that report no differences between laboratory and real-life situations (e.g., De Wijk, Kaneko, Dijksterhuis, Van Zoggel, Schiona, Visalli, et al., 2019; Zandstra, Kaneko, Dijksterhuis, Vennik & de Wijk, 2020). The physical context in which foods are consumed is only one of several dimensions that together determine the food experience. 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 but the mechanism behind these effects is largely unknown. An important question relates to the dependency of the effects of the dimensions on food experiences. For example, are all foods experienced more positively in a pleasant environment, or only those foods that are associated – or congruent- with that specific environment (i.e., are all foods experienced more positively in our favorite Japanese restaurant or only Japanese foods)? Van Bergen et al. (2020) found negative effects on liking of incongruent context-food combinations (e.g., sushi consumed at the beach) compared to congruent combinations such as sushi consumed in a sushi restaurant. The effects were small and were primarily related to anticipated liking rather than actual liking. More specifically, liking of congruent foods changed little during repeated exposures. In contrast, liking of noncongruent foods did change during repeated exposures. It is not clear whether these changes reflect actual changes in liking or an initial inability of participants to anticipate how a food will taste in a context that is not normally associated with the food. These results suggest at least some dependency between context and the type of consumed foods, and context-food congruency cannot be ruled out as a possible explanation for the inconsistent results of context-food studies. On the other hand, hedonic measures, such as liking scores used in most food studies, may lack sensitivity to capture the full food experience, and studies so far may actually underestimate the effects of context on food experiences.

Recently, it was argued that so-called implicit measures may be better suited to capture the complexity of real-life food experiences than explicit measures such as liking scores (de Wijk & Noldus, 2020a, 2020b). Implicit measures monitor (food) experiences indirectly via their effects on 1) the activity of the central nervous system, such as EEG and MRI, 2) the activity of the autonomic nervous system such as skin conductance and heart rate, 3) expressive responses, such as facial expressions, and 4) behavior, such as the speed with which food is sampled. 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 liking ratings. In contrast, implicit facial expressions and heart rate frequency measurements did show systematic effects: Compared to consumption in the laboratory, consumption of all foods at home was faster, triggered higher heart rates, and triggered more intense facial expressions of happiness, contempt, disgust and boredom. The effect of congruency on implicit measures was not investigated in this study because food-contexts congruencies were not systematically varied. A direct comparison between the results of implicit and explicit measurements itself is somewhat meaningless because of the different natures of the measurements. For example, a liking score reflects various aspects of the food (e.g., expectations, familiarity, sensory properties) in one single liking score that is typically generated at the end of consumption. This means that the relative contributions of each of the aspects as well as their development over time is unknown. In contrast, implicit measures are typically continuous and specific implicit measures can be selected to reflect specific aspects of the food (e.g., skin conductance responses and facial expressions associated with the food's novelty (e.g., de Wijk and Noldus 2020a&b). Hence, the variety of implicit measures as well as their continuous nature offers by definition a much richer source of consumer' responses to foods. More research is needed, however, to determine whether this richness offers additional insights into mechanisms underlying consumer acceptance of foods that can be used for example to stimulate healthier and/or more sustainable food choices.

For the present study unpublished results of facial expression measurements and explicit emotional responses will be used that have been collected as part of the van Bergen study (2020). In that study congruent and non-congruent food-context combinations were tested using immersive technologies to recreate the physical context of a consumption situation in a laboratory with visual, auditory and olfactory cues. Previous studies suggest that the use of immersive technologies can improve the predictive validity and reliability of liking scores in consumer testing (e.g. Andersen, Kraus, Ritz, & Bredie, 2018; Bangcuyo, Smith, Zumach, Pierce, & Guttman, 2015; Delarue, Brasset, Jarrot, & Abiven, 2019; Sinesio, Saba, Peparaio, Saggia Civitelli, Paoletti, & Moneta, 2018; Hannum, Forzley, Popper & Simons, 2019). Van Bergen (2020) showed that participants reported high degrees of immersion during exposure to the recreated contexts which was corroborated by the differences in liking scores for the same foods presented in different immersive contexts.

For the present study it is hypothesized that:

1) Facial expressions and self-reported food-evoked emotions during consumption of test foods reflect properties of the foods and of the (immersive) context.
2) Effects of foods and contexts on facial expressions and self-reported food-evoked emotions are not independent but vary with context-food congruency.

2. Material and methods

The materials and methods will be summarized here with a special focus on the facial expressions and food-evoked- and general emotions. A more detailed description can be found in Van Bergen et al. (2021).

2.1. Participants

Forty-two participants were recruited for this study from the Wageningen University & Research participant database. Given the elaborative study design that allows only a relatively small number of participants, it was decided to recruit a relatively homogeneous group of participants. Participants had to meet the following inclusion criteria: (1) Age between 18 and 65 years, (2) Dutch native language, (3) Healthy (self-reported), (4) BMI between 18.5 and 27 kg/m^2 (self-reported), (5) Normal ability to taste and smell (self-reported), and (6) Having consumed each of the food products used in the study at least once in the past year (self-reported). In fact, participants indicated that they consumed sushi and popsicle at least once per three months, and iced tea at least once per month. Selected participants were randomly assigned to one of the two groups: the first group was repeatedly exposed to the beach context (Beach group), the second group was repeatedly exposed to the restaurant context (Restaurant group). Participants signed

informed consent prior to the start of the experiment. The study was approved by the social sciences ethics committee of Wageningen University and Research.

2.2. Products

This study included samples of three commercially available foods: 1) 3 pieces of sushi ('*kappa maki*', sushi rolls with cucumbers dipped in a little soy sauce (Kikkoman), freshly prepared daily by a local sushi restaurant), 2) 200 ml of green iced tea (brand: Lipton), and 3) one popsicle (brand: Ola Raket). Given the relatively new and unusual procedure of the ratings and facial expression measurements, a fourth food, 20 g of potato chips (brand: Lays), was used as practice food and the results were excluded from further analysis. This practice food was presented as first test food on days 1, 7, and 8. The foods/drinks were presented on small porcelain trays or in a glass. They were selected based on their "fit" or congruency with one or two of the immersive contexts, which was established in a pilot study prior to the actual study (see van Bergen et al. (2021) for details). Sushi is congruent with the restaurant and incongruent with the beach. In contrast, popsicle is incongruent with the restaurant and congruent with the beach, whereas iced tea is congruent with both the restaurant and the beach. The results of the three foods that were presented in all eight sessions will be reported here. Presentation order of foods/drinks was randomized with the software TimeSens® (ChemoSens, Dijon, France) according to a William's Latin Square experimental design.

2.3. Procedure

The two groups of participants, the 'beach group' and the 'restaurant group', were tested repeatedly during two consecutive periods of approximately two weeks during the summer of 2019. Each group was split up in subgroups of 4 to 7 participants. The composition of the subgroups was kept constant across sessions to facilitate social interactions and reduce feelings of discomfort. In total, each subgroup participated in 8 sessions of 45 min per session. The first seven sessions occurred in the same immersive context. In the eighth session, the immersive contexts were switched between groups. In sessions 1, 7, and 8 test foods (see scheme 1) were consumed, and liking, food-evoked emotions as well as facial expressions were recorded. During sessions 2–6 ("exposure sessions"), the test foods were continued to be consumed but no specific questions were asked regarding these foods. Instead, participants were free to interact with each other and filled out questionnaires unrelated to the foods, such as a questionnaire regarding general emotions experienced during that session.

During the sessions 1, 7 and 8 participants would sit down at tables in front of laptops equipped with built-in webcams (Lenovo Thinkpad L580). The food trays would be placed in front of them, and participants rated "desire to eat" and "expected liking" based on the visual food cues. Subsequently, they were instructed to look in the webcam for the recording of facial expression, while they took the first bite/sip/lick of one of the foods and process the food for at least 10 s in the mouth. When the food was swallowed, the participant pressed the "NEXT" key and rated liking using TimeSens software® (ChemoSens, Dijon, France). Next, participants took another bite/sip/lick of the same food, but this time emotions (and food attributes of which the results will not be reported here) were measured. After 1 min this procedure was repeated for the other foods. Water was used to cleanse the palate between foods. During the rest of the session the participants had time to socialize with each other as long as they did not discuss the food samples, and to finish their foods if they wanted to.

2.4. Contexts

The two immersive contexts were a simulated version of an actual sushi restaurant in Wageningen and a simulated beach (see Image 1). Testing took place in the so-called Experience Room in the Helix building of Wageningen University & Research. For the *immersive restaurant context* photographic footage of the real sushi restaurant was projected on all four walls using eight projectors. A recording of the sounds in the restaurant was played through the speaker system. The room was lit with spots that were set to give somewhat yellow light, similar to the lighting in the restaurant. The chairs were consistent with the theme of the restaurant. Participants were asked to take a seat, three persons per table. They were allowed to talk during the whole session, as long as they would not discuss the samples. For the immersive beach

SESSION		Pre exposure	Initial exposure	Repeated exposure	Post exposure – same context	Post exposure – switch context
Day		-1	1	2 3 4 5 6	7	8
Beach group	Context		BEACH	BEACH	BEACH	SUSHI RESTAURANT
	Products		Sushi - Popsicle - Iced tea	Sushi – Popsicle - Iced tea	Sushi – Popsicle - Iced tea	Sushi - Popsicle - Iced tea
Restaurant group	Context		SUSHI RESTAURANT	SUSHI RESTAURANT	SUSHI RESTAURANT	BEACH
	Products		Sushi - Popsicle - Iced tea	Sushi - Popsicle - Iced tea	Sushi - Popsicle - Iced tea	Sushi – Popsicle - Iced tea
Measures	*Product-Related*	*Situational appropriateness*	*Expected liking* *Desire to eat* *Liking* *Sensory attributes* **Self-reported food-evoked motions** **Food-evoked facial expressions**	*Situational appropriateness (day 6)*	*Desire to eat* *Liking* *Sensory attributes* **Self-reported food-evoked motions** **Facial expressions**	*Desire to eat* *Liking* *Sensory attributes* **Self-reported food-evoked motions** **Food-evoked facial expressions**
	Context-related				*Contextual engagement*	*Contextual engagement*
	Other			**General emotions** *Personality (Big five)* *Food Neophobia* *Restraint Dutch eating behaviour* *Health & attitudes*		

Scheme 1. Experimental design and procedure, split up by exposure group. Food-context congruity is indicated by font color: contextually congruent foods in green, contextually incongruent foods in red, control foods in grey. Results of the measures in bold are reported in here. Results of the other measures in italic have been reported by van Bergen et al. (2020).

Image 1. Impressions of the immersive beach (left) and sushi restaurant (left) contexts.

context photographic footage of an actual beach was projected on all four walls and actual beach sounds were played. The floor was covered with a carpet that resembled the color and texture of sand. A sunscreen aroma was used to further enhance the immersiveness of the beach context. Participants were seated in beach chairs and foldable tables were used for the placement of test foods and drinks. Again, participants were allowed to talk, as long as they would not discuss the samples.

2.5. Measurements used in the study

Measurements of emotions will be described here (see van Bergen et al. (2021) for the other measurements). Emotions were measured by recording facial expressions and explicitly with questionnaires. For comparability the descriptions of the explicit emotions in the questionnaire matched the emotions that the facial recording system would infer. Food-evoked facial expressions and explicit emotions were recorded during consumption of test foods in the initial exposure (session 1) and the two post-exposure sessions (sessions 7 and 8). General explicit emotions, i.e., emotions that were not associated with consumption of test foods but with general feelings, were recorded during the exposure sessions (i.e., sessions S2-S6 where test foods were consumed but where no specific food tests were conducted). An overview of the sessions and measurements is given in scheme 1.

Facial expressions. Video segments of ten seconds starting from the moment that the food/drink was put in the mouth for the first time prior to the scoring of liking, were used for analysis of facial expressions. FaceReader scores were averaged across these ten seconds. Video segments were stored together with the participant's code, the product code, and time and date information. Facial expression data were automatically analysed by FaceReader 8.0 (Noldus Information Technology, Wageningen, The Netherlands) in three steps. The face is detected in the first step using the Viola-Jones algorithm (Viola and Jones, 2001). Next, the face is accurately modelled using an algorithmic approach (den Uyl and van Kuilenburg, 2005). Finally, the actual classification of the facial expressions is based on an artificial neural network trained with 10,000 manually annotated images. The face classification provides the output of seven basic expressions (happy, sad, angry, surprised, scared, disgusted and contempt) on the basis of the Facial Action Coding System developed by Ekman and Friesen (1978) plus one neutral state. Sad, angry, scared, and disgust are considered as negative emotions, happy is considered a positive emotion. Specific basic emotions are also combined in arousal and valence dimensions. Valence is calculated from the score of the happiness emotion minus the score of the most intense negative emotion. Basic emotions are analysed per time frame of 0.04 sec. In addition, longer term changes (over 2 to 5 s) in expressions, "affective attitudes" of interest, boredom, and confusion, are analysed.

FaceReader scores for each emotional expression range from 0 (emotion is not detected) to 1 (maximal detection), with the exception of valence which range from −1 to 1) and is based on intensity judgments of human experts collected during the development of the FaceReader methodology. FaceReader allows for the simultaneous presence of multiple emotions.

Similar basic emotions as the ones captured by FaceReader (scared, happy, angry, interested, calm, sad, surprised, and disgusted) were also used for the measurement of general and food-evoked emotions. Food-evoked emotions were measured during consumption of each of the test foods. General emotions were measured during other test days and were not associated with the consumption of test foods (see scheme 1).

General explicit emotions. Participants were asked to indicate how they felt in that moment by rating each of the emotions on a 4-point scale (1 = not at all, 4 = very much).

*Food-evoked explicit emotions***.** Participants indicated how strong they felt each of the emotions while tasting each of the samples. Participants rated on a 4-point scale (1 = not at all, 4 = very much).

2.6. Data analysis

Only the results of the three foods (iced tea, sushi and popsicle) that were presented in all eight sessions were used in the analysis. Seven participants had incomplete videos due to technical problems (e.g., internet failure that prevented the upload of the images to a server) and were omitted from all analyses, i.e., analysis was only based on 35 participants with complete data sets. A previous study with similar measures demonstrated relatively large effects of location on facial expressions in (de Wijk et al. 2019). For the present study, a power calculation indicated that a total number of participants of 30 would be sufficient to demonstrate an effect of congruity. G*Power software (V3.1.9.6) with alfa = 0.05, beta = 0.8, medium expected effect size f = 0.25, for a repeated measured design with between and within factors). Statistical analyses were performed with mixed model ANOVAs (using IBM SPSS statistics, version 22) with participant as random factor. For the analysis of the effects of *exposure group* on facial expressions and emotion scores, results of the first and seventh sessions were used with exposure context (2, beach vs. sushi restaurant), test number (2, pre- and post-exposure and product (3) as fixed factors. For the analysis of *exposure group*, the exposure context was a between-subject variable because approximately half of the participants were repeatedly exposed in sessions 1–7 to the beach context and the other half to the restaurant context. For the analysis of the effect of *test context* on expressions and scores, results of the seventh (post exposure, same context) and eighth (post-test, different context) sessions were used with exposure context (2), test context (2) and product (3) as fixed factors. In this case test context was a within-subject variable because approximately half of the participants were first tested in the beach context (session 7) followed by the restaurant context (session 8) whereas the order was reversed for the other half of the participants. Congruity effects should reveal themselves by significant interactions between product and exposure and/or test context. Mixed model results as well as the corresponding estimated marginal means will be reported below in the result section. For significance an alpha criterium of 0.05 was used.

3. Results

First, the effects of exposure group (sessions 1 & 7) on explicit general and food-evoked emotions, and on food-evoked facial expressions will be presented, followed by the effects of test context (sessions 7 and 8) on food-evoked emotions and facial expressions.

Effect of exposure group on general explicit emotions. General emotion profiles varied between exposure groups (interaction: $F(7,592) = 4.1$, $p < 0.001$), and did change significantly between pre- and post-exposure (interaction: $F(7,592) = 5.1$, $p < 0.001$). After repeated exposure, participants felt significantly less interested, calmer, and less surprised (all $p < 0.05$) compared to initial exposure. Moreover, participants exposed to the beach context felt overall more interested, calmer, and more surprised than participants exposed to the restaurant context (all $p < 0.05$).

Effect of exposure group on food-evoked explicit emotions. Emotion scores varied between foods (interaction: $F(14,1768) = 4.9$, $p < 0.001$). Happiness, interest and surprise were stronger for sushi than for popsicle and iced tea, and calmness was stronger for sushi and iced tea than for popsicle ($p < 0.05$, see Fig. 1). Emotion scores also varied between exposure groups (interaction: $F(7,1768) = 2.7$, $p < 0.05$); food emotions during exposure to the beach context were more happy, interested, and surprised and less calm than during exposure to the restaurant context (all $p < 0.05$) (Fig. 2). The effects of exposure group were not food-specific as indicated by the lack of significant food-context interaction ($F(2,1860) = 0.28$, n.s.). Emotions did change significantly over repeated exposures (interaction: $F(7,1768) = 8.0$, $p < 0.001$). After repeated exposure, food-evoked (similar to general) emotions were significantly less interested and less surprised ($p < 0.05$), irrespective of the food or context.

Effect of exposure group and foods on food-evoked facial expressions. Facial expression profiles varied between foods ($F(18,2270) = 3.70$, $p < 0.001$) (Fig. 3). Significant food product differences were found for expressions of sadness, disgust, as well as overall valence and neutral (all $p < 0.05$). Facial expressions for sushi were sadder and more negatively valenced than expressions for the other foods. Facial expressions for iced tea were more disgusted. Profiles varied significantly with context (interaction: $F(9,2270) = 4.0$, $p < 0.001$): foods presented in the immersive beach context triggered more neutral expressions, fewer expression of sadness and disgust, and were in general less negatively valenced than the same foods presented in the restaurant context (all $p < 0.05$) (Fig. 4). The effect of context was not food specific as indicated by the lack of significant interactions between foods and context over time ($F18,2270) = 0.38$, n.s.). Facial expressions did not change systematically after repeated exposure (no significant main and/or interaction effects).

Effect of test context on food-evoked explicit emotions. Food-evoked emotions did not change when participants switched to a different context (session 8) after repeated exposures to the other context (sessions 1–7). For example, participants' positive food-evoked emotions such as happiness and interest during repeated exposure in the beach context continued to be positive when these participants switched to the restaurant context.

Effect of test context on facial expressions. Facial expression profiles after the switch in session 8 again varied between foods (interaction: $F(18,2270) = 5.1$, $p < 0.001$), similar to the results shown in Fig. 3. Facial expressions varied significantly with the previous context (session 1 & 7) (interaction: $F(9,2270) = 3.2$, $p < 0.01$) and with the new context (session 8) (interaction: $F(9,2270) = 3.7$, $p < 0.001$), i.e., expressions did not only vary with the context at the moment of testing, but also varied with the context in which the foods had previously been presented. Foods tested in the beach context triggered more expressions of arousal and surprise, fewer expressions of disgust, and were in general more neutral and positively valenced than the same foods tested in the restaurant context (all $p < 0.05$) (see Fig. 5). Participants that had previously been exposed to the foods in the beach context showed more expressions of anger and disgust, and fewer expressions of sadness than the participants that had previously been exposed to the restaurant context ($p < 0.05$).

4. Discussion

Previously it was found that explicit liking ratings primarily reflect properties of the foods and that effects of consumption context were limited to anticipated liking of congruent- and non-congruent food-context combinations (van Bergen et al. 2020). For the present exploratory study, it was hypothesized that: 1) Facial expressions and self-reported food-evoked emotions during consumption of test foods reflect properties of the foods and of the (immersive) context, and 2) Effects of foods and contexts on facial expressions and self-reported food-evoked emotions are not independent but vary with food-context congruency.

The results showed that self-reported food-evoked emotions and facial expressions varied with the test foods, and with the context in

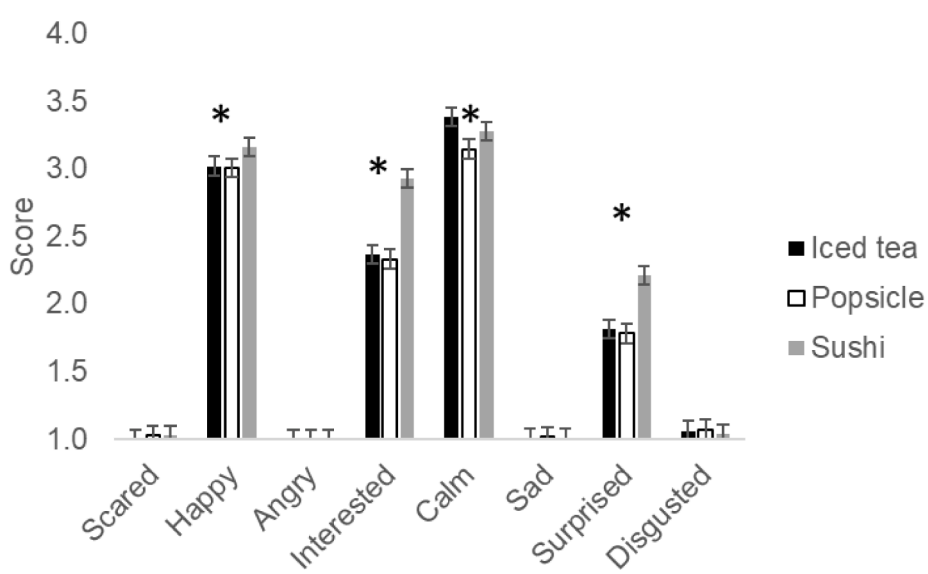

Fig. 1. Effect of test food (session 1–7) on food-evoked emotions. Food evoked emotions are averaged across repeated exposures and immersive contexts. Significant effects are indicated by *.

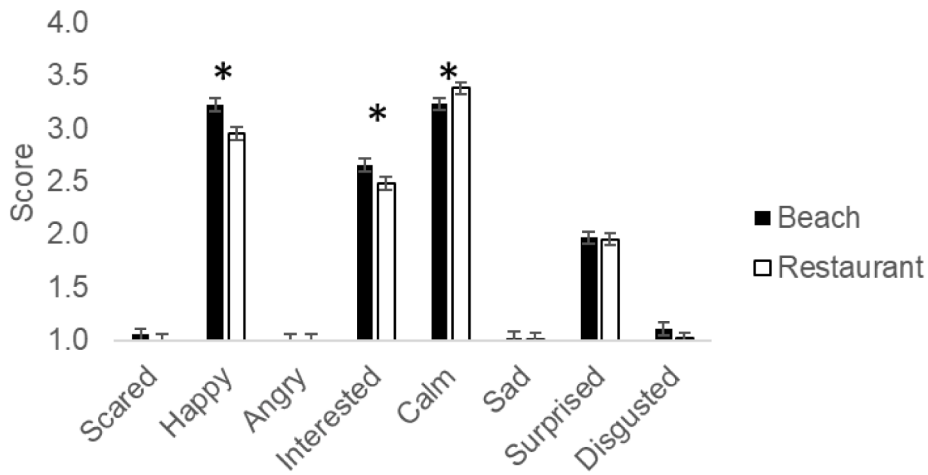

Fig. 2. Effect of immersive context on food-evoked emotions. Food evoked emotions are averaged across repeated exposures (session 1–7) and foods. Significant effects are indicated by *.

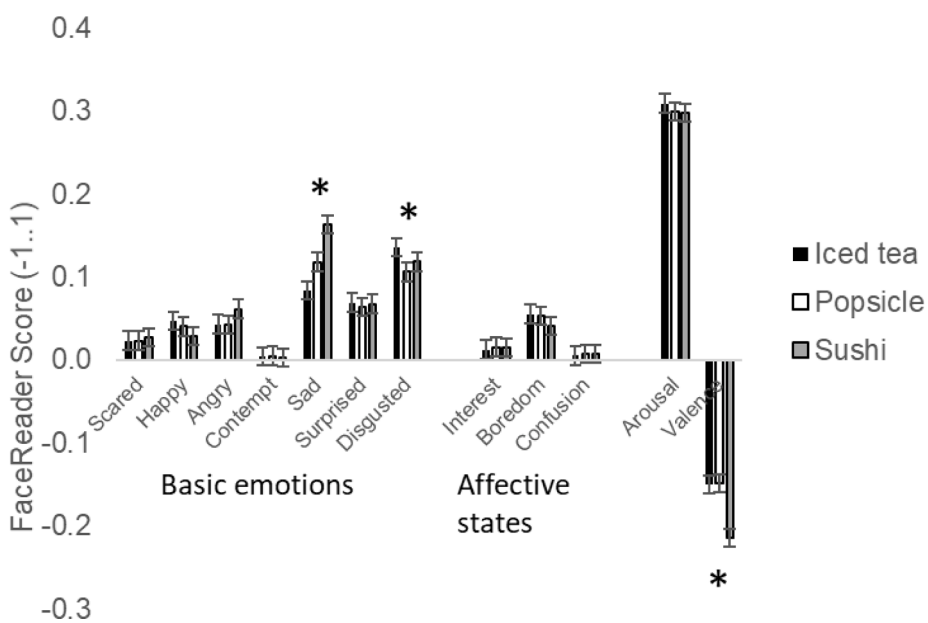

Fig. 3. Effect of foods on facial expressions. Facial expressions are averaged across repeated exposures (sessions 1–7), and immersive contexts.

which the foods were repeatedly consumed. The effects of context and test foods were independent, i.e., the effects of contexts were similar for congruent- and incongruent food-context combinations. Hence, the first hypothesis was confirmed, and the second hypothesis was disconfirmed. Thus, facial expressions, as well as self-reported food evoked emotions, showed larger sensitivity compared to explicit liking scores (reported by van Bergen et al. 2020) for context effects, but the lack of congruency effects suggests independent effects of contexts and foods.

The effects of context on food-evoked self-reported emotions and facial expressions are probably mediated by longer-lasting effects of context on emotions (or mood). Self-reported food-evoked emotions followed closely general self-reported emotions: compared to the restaurant context, participants felt more interested, less calm and more surprised in the beach context not only during periods of consumption but also before and after. Similarly, facial expressions during consumption in the beach context were more positively valenced compared to the restaurant context. Or in other words, people feel better in certain contexts compared to other contexts, irrespectively whether they eat sushi, lick a popsicle, or drink iced tea. This result is probably not a surprise for the hospitality industry where restaurants are designed to optimize customers' experiences. Somewhat surprising is that the results of this study suggest that it may not be necessary to make the type of food consistent with the theme of the restaurant. In the extreme case, this may imply that good Chinese food is experienced equally positive in a nice Chinese restaurant and in a nice Italian restaurant. Obviously, additional research is needed to explore possible boundaries of the (lack of) congruency effects.

Despite the similarities of the results of food-evoked emotions and facial expressions, there are also differences. For example, repeated exposures to a specific context affect both food-evoked emotions and facial expressions, but a subsequent switch to another context lead only to additional effects on facial expressions, and not on food-evoked emotions. This suggests that food-evoked emotions settle during repeated exposures to one context and no longer change after a switch to another context. In contrast, the sensitivity of facial expressions to context effects seems to persist after a switch. Another difference between food-evoked emotions and facial expressions relates to food-specificity of the results. For example, sushi was associated with relatively strong self-reported emotions of happiness, interest and surprise whereas the facial expressions were more negatively valenced.

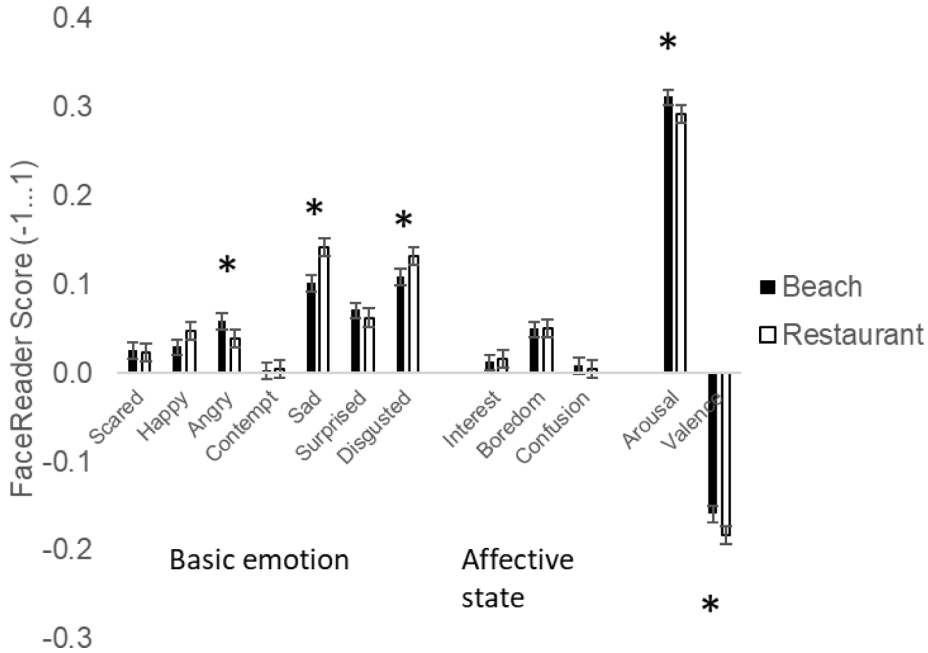

Fig. 4. Effect of immersive context on facial expressions. Facial expression scores are averaged across repeated exposures (sessions 1–7) and foods. Significant effects are indicated by *.

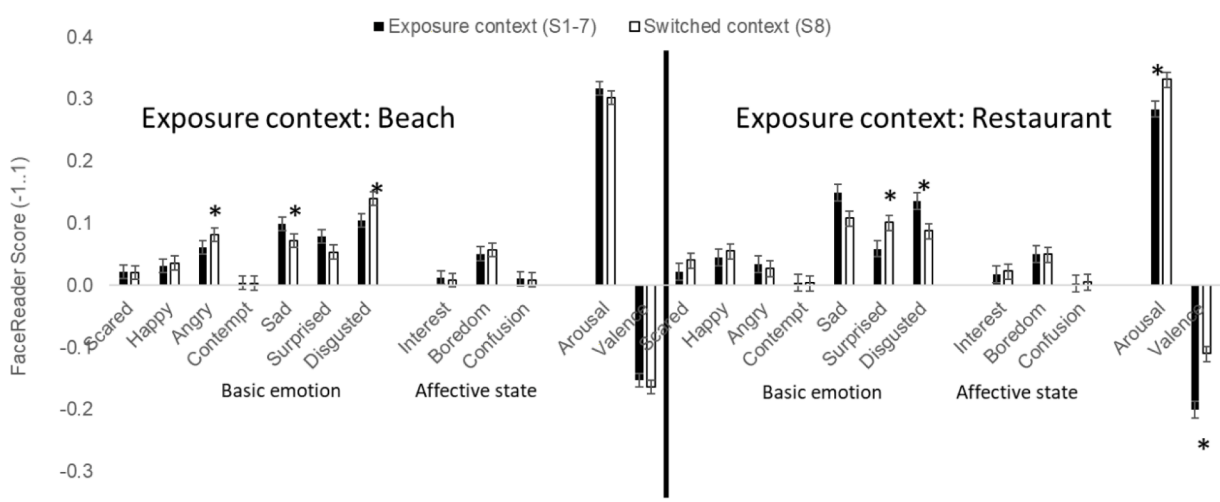

Fig. 5. Facial expressions during exposure to the beach or restaurant exposure (Sessions 1–7) and after the switch to the other context (Session 8). Facial expression scores are averaged across foods. Significant effects are indicated by *.

Similarly, sushi, and iced tea, also evoked stronger self-reported emotions of calmness than popsicle, whereas no food-specific effects were found for facial expressions of arousal. Finally, self-reported food-evoked emotions showed systematic changes during repeated exposure that were independent of the specific foods, whereas facial expressions showed no systematic effects of repeated exposure. These different results suggest that self-reported food-evoked emotions and facial expressions reflect (partly) different aspects of the foods. For example, self-reported emotions may relate more to hedonic aspects of the foods, whereas facial expressions (as well as implicit measures in general) may relate more to other aspects of the foods such as its novelty and fit with expectations (see also de Wijk and Noldus, 2020a&b). Obviously, further studies are needed to investigate these differences between explicit (self-reported) measures and implicit measures/facial expressions in more detail.

The immersive contexts used in this study clearly affected the way participants felt as evidenced by reported emotions and facial expressions. Participants exposed to the immersive beach context report that they feel more interested, surprised and calm than participants exposed to the immersive restaurant context. This was corroborated by the facial expressions, that were more positively valenced in the immersive beach context compared to the restaurant context. Interestingly, as was discussed above, the effects of context on emotions were similar for food-specific self-reported emotions and for general (i.e., non-food related) self-reported emotions, which suggests that general emotions triggered by the consumption context are projected on the foods.

These differences between contexts in emotions and facial expressions could have been caused by individual differences between participant groups, because one group was repeatedly exposed to one context and another group was repeatedly exposed to the other context. However, when the participants who were repeatedly exposed to the restaurant context switched to the beach context, their facial expressions became more positively valenced, which suggests that the effects are

primarily caused by the context rather than by individual differences between participants. This corroborates findings from a previous study in which participants were tested in their home and in the lab, and where facial expressions at home were found to systematically differ from those in the lab, irrespective of the food (de Wijk et al. 2019). The effects of immersive context on explicit emotion scores found in the current study – and on liking scores in the van Bergen et al study (2022)- were larger than the effects found previously in a study where soups were tested in a real-life and immersive grand cafe context, and in a neutral sensory laboratory (Zandstra et al., 2020). In that study, virtually no differences in test scores were found between the various contexts. One of the differences between that study and the present study was that in the Zandstra study participants' focus was on the test products and any distractions from for example social interactions were discouraged. In the present study, social interactions were encouraged during periods when participants were not occupied with the test products. Especially in the beach context, participants seem to feel relaxed and open for social interactions. This seemed to be facilitated by the availability of beach attributes such as an inflatable beach volleyball which resulted in more movements and increased social interactions. Social interactions may have added considerably to the degree to which participants felt immersed in the test contexts, which in turn affected their food experiences. Even though the immersive beach context in this study is clearly experienced differently by our participants than the immersive restaurant context, future research should verify whether the experiences in each of the immersive contexts are similar to the experiences in their real-world counterparts.

An obvious limitation of this study is the relative low number of participants per test condition, due to the limited number of participants that could be tested simultaneously and the large number of sessions. Another limitation is the limited number of immersive contexts. For this study, contexts were selected that were either very congruent or very non-congruent in relation to the test foods. Future studies may use contexts that are for example more neutral, i.e., that are congruent to a wider range of foods. Furthermore, this study compared only two immersive contexts, and no real-life and/or a CLT (central location test as negative control) context. Hence, no conclusions can be drawn whether similar results would be obtained if the test were carried out at a real beach or in a real-life sushi restaurant.

In conclusion, the results show that 1) physical and social consumption contexts that are recreated in the laboratory affect general and food-evoked emotions measured with self-reported emotions and facial expressions, 2) foods and contexts affect food-evoked self-reported emotions and facial expressions independently, and 3) results of self-reported food-evoked emotions and facial expressions showed similarities but also differences pointing at the added values of facial expressions.

CRediT authorship contribution statement

R.A. De Wijk: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **D. Kaneko:** Conceptualization, Writing – original draft, Writing – review & editing. **G.B. Dijksterhuis:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **G. van Bergen:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **M.H. Vingerhoeds:** Conceptualization, Writing – review & editing. **M. Visalli:** Methodology, Writing – original draft, Writing – review & editing, Supervision, Project administration. **E.H. Zandstra:** Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This work was supported by a grant from the Dutch Top Consortium for Knowledge and Innovation (TKI) Agri&Food together with Unilever Foods Innovation Centre Wageningen, The Netherlands, Kikkoman Europe R&D Laboratory and Noldus Information Technology (TKI-AF-17005). We would like to thank Anaim Klein and Maria Teresa Castillo for helping in the data collection, Saskia Meijboom for her help with the recruitment of subjects and João Paulo for her statistical advice.

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