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Proceeding Paper

Effects of Multisensory Contexts on Tofu and Soy Sauce Evaluation and Consumption †

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Abstract: We examined the effects of an informative pitch and multisensory contexts as potential factors influencing individuals' experience of tofu with soy sauce and the amount consumed outside the lab. Two hundred and sixteen participants watched one of two pitches (promoting either vegetarian diets or exercise) and were guided into one of three multisensory contexts ('sustainable', 'meat', or 'neutral' theme). Participants rated the aroma and appearance of soy sauce and the taste of tofu dipped in it using the intuitive 'one touch' EmojiGrid valence and arousal measuring tool. Our results showed that the 'meat' context increased arousal ratings for soy sauce and the tendency to consume more tofu relative to the other contexts. Pitch did not influence affective ratings or amounts consumed. We conclude that the multisensory context has the potential to positively affect peoples' choices and perceptions of plant-based and sustainable food and promote its consumption.

Keywords: food evaluation; food consumption; multisensory context; vegetarian

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1. Introduction

It is important to motivate healthy and sustainable food behavior for the environment and public health. Here, we examine whether we can affect the appreciation and consumption of relatively unfamiliar, vegetarian food (uncooked tofu with soy sauce) by providing top-down information (an informative pitch) and manipulating the environmental context in which the food is tasted and examine whether these factors interact.

Multiple studies have shown that contextual cues, such as tableware and background music during food consumption, can change sensory perceptions [1–5]. In addition, the effect of multisensory contexts has been investigated. It was shown that in a natural ambience including visual and auditory stimuli, people more often chose vegetarian dishes than in a customary ambience [6]. One study conducted in restaurant dining contexts has shown that multisensory lunch conditions, including nature-themed images, sounds, and odors, positively influenced food-evoked emotions [7].

Besides contextual effects, effects of top-down information (i.e., videos) on food-related behavior have been reported as well. For instance, Bschaden et al. [8] used videos to inform people about the impact of sustainable dietary behavior and showed that this information can affect consumers' perception in the desired direction. In another study using video clips as goal-priming stimuli, direct priming of a health goal proved to be effective in steering consumers towards healthier food options [9].

Although several studies have reported the effects of top-down information and context on food experience, to our knowledge, there is no study examining the combination of both. Furthermore, the above-mentioned studies were conducted using largely controlled laboratory settings, making it unclear whether these top-down and contextual effects generalize to more naturalistic real-life contexts.

When recording outside the lab, it is important to use sensitive, intuitive tools to record participants' responses. The EmojiGrid (Figure 1) is such a tool to assess food-evoked emotional experiences in an intuitive, language-independent way [10]. Users express their emotions by indicating the matching location in a valence–arousal grid where emotions are indicated by emojis.

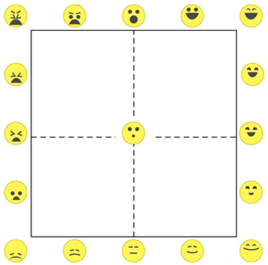

Figure 1. The EmojiGrid: an emoji labeled affect grid for the measurement of food-related affective associations. The facial expressions of the emoji vary from disliking (unpleasant) via neutral to liking (pleasant) along the horizontal (valence) axis and a gradual increase in arousal along the vertical axis. Respondents touch a location in the grid matching their experience.

In this study, we vary the top-down information (pitch) and the multisensory context and use an EmojiGrid and amount consumed (an implicit behavioral measure) to assess food experience outside the lab. We expect positive effects of vegetarian pitch and sustainable context and the combination effect thereof on tofu appreciation and the amount consumed.

2. Materials and Methods

2.1. Participants

We recruited 232 participants from a music festival (Lowlands, The Netherlands). People with allergies to gluten, soybeans, nuts, or peanuts, and who did not understand Dutch were excluded beforehand. Participants were naïve as to the purpose of the experiment. The study was approved by the TNO Institutional Review Board (Approval Ref: 2021-071) and signed informed consent was obtained prior to the experiment.

Participant data were excluded when they (1) did not follow the instructions (occurred four times) or had trouble understanding Dutch (two), (2) knew the purpose of the research beforehand (two), or (3) had a loss of smell and/or taste (eight). Of the remaining 216 participants, 43.1% were male and 56.9% were female. The participants' mean age was 31.1 (SD 10.0 years) and the mean BMI was 23.5 $\pm$ 3.0 (kg/m^2).

2.2. Materials, Design, and Procedure

The study was carried out at the three-day Lowlands festival (19–21 August 2022, Biddinghuizen, The Netherlands). The experiment used a 2 (pitch) $\times$ 3 (context) between-subjects design. Participants were exposed to either a pitch that promoted vegetarian food or a body exercise by neuropsychologist Professor Erik Scherder, who is a well-known Dutch neuropsychologist. In the exercise pitch, he explained how body exercise positively

influences the brain, and in the vegetarian pitch, he explained that meat production and consumption can have negative consequences on the environment, animal welfare, health, and body odor.

After watching the pitch, participants were guided towards a room where we manipulated the multisensory context (sustainable, meat, neutral; see Figure 2). Each context was designed with matching objects such as posters, tablecloths, table lights, and trays. Matching scents (air freshener 'Lavender' for sustainable, smoke aroma liquid for meat, no odor for neutral) and music (respectively meditation–nature, country, and elevator music) were presented. Participants tasted and rated different types of hotdogs (methods and results presented elsewhere). After that, they rated the aroma and appearance of a cup of soy sauce using the EmojiGrid. Next, they were presented with four approximately $1 \times 1 \times 1$ cm cubes of uncooked tofu with a small flag displaying '100% plant-based'. They were asked to rate the taste of tofu after having dipped it in soy sauce using the EmojiGrid, as well as tofu firmness and saltiness using 10-point Likert scales. Participants could taste as many pieces (with a maximum of four) as they liked, and the number of consumed pieces was recorded. Responses were provided and recorded using dedicated smartphones.

Figure 2. From left to right, the three different contexts: sustainable, meat, and neutral.

2.3. Analysis

SPSS version 28.0.1.1 was used to analyze the data. We conducted one-way ANOVAs on the valence and arousal ratings for soy sauce appearance and aroma, using valence and arousal when tasting soy sauce and tofu, the number of pieces consumed, and tofu firmness and saltiness with pitch and context as between-subject variables. p-values were Bonferroni-corrected, and alpha was set to 0.05. All significant effects and all effects with $p < 0.10$ are reported in the Section 3.

3. Results

3.1. Valence and Arousal in Soy Sauce and Tofu Evaluation

No effect of pitch on the evaluation of soy sauce was observed. Context did affect the evaluation of soy sauce. Specifically, post hoc paired comparisons indicated that the 'meat' context increased arousal relative to the other contexts for the appearance and aroma evaluation (Figure 3). Also, arousal in the 'meat' context was higher than in the 'sustainable' context for the taste evaluation. Interaction effects of pitch and context were not observed.

3.2. Amount of Tofu Consumed

Pitch did not affect the amount consumed. Regarding context, and consistent with the arousal judgements, the group exposed to the 'meat' context tended to eat more pieces of tofu ($p = 0.087$) compared to the 'neutral' context (Figure 4). Interaction effects of pitch and context were not observed.

3.3. Sensory Attributes of Tofu

Pitch did not affect perceived saltiness. On the other hand, tofu was rated as less salty in the 'meat' context compared to the 'neutral' context (Figure 5). The perceived firmness was influenced by both the pitch and context. Tofu was rated less firm after exposure to the vegetarian pitch compared to the exercise pitch, and firmer in the 'meat' context compared to the 'neutral' context. No interaction between the pitch and context was observed.

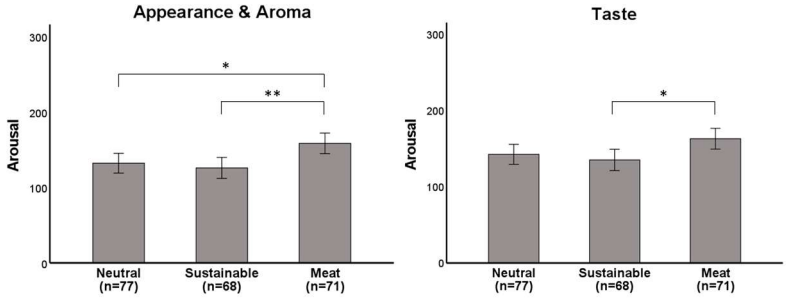

Figure 3. Mean arousal rating as a function of context (neutral, sustainable, meat) for appearance and aroma (left panel) and taste (right panel) of soy sauce and tofu (* $p < 0.05$, ** $p < 0.01$). Arousal scores run from 0 to 300 (pixels). Error bars represent standard errors of the mean.

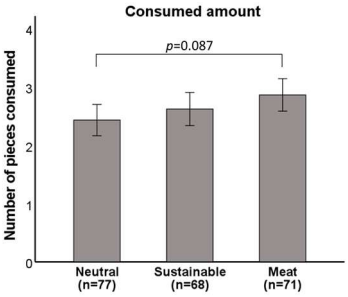

Figure 4. Mean number of pieces consumed tofu as a function of context (neutral, sustainable, meat). Error bars represent standard errors of the mean.

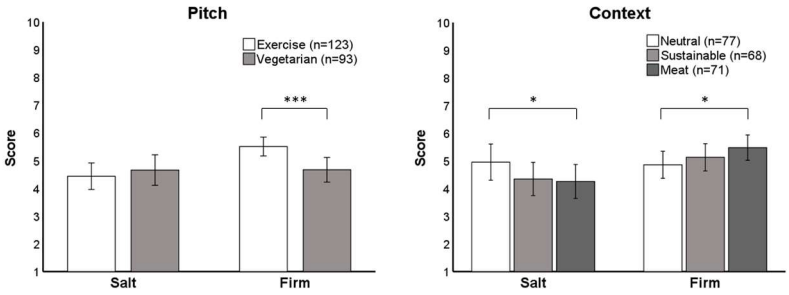

Figure 5. Mean scores of perceived tofu saltiness and firmness as a function of pitch (exercise and vegetarian) and context (neutral, sustainable, meat) (* $p < 0.05$, *** $p < 0.001$). Error bars represent standard errors of the mean.

4. Discussion

The purpose of this study was to determine whether top-down information and multisensory contexts can affect the appreciation and consumption of (vegetarian) food and whether these factors interact.

Our results show that the multisensory context affected the evaluations of soy sauce and tofu and tends to affect the amount consumed. The 'meat' context increased arousal and tended to increase the amount consumed relative to the other contexts. This was contrary to our expectation that a sustainable context would lead to an increase in the acceptance of vegetarian food. We speculate that this result is caused by the 'meat' context being closer to a restaurant environment than other contexts in terms of the surrounding objects and scent. This would be in accordance with previous work indicating that similar meals were rated higher when served in restaurants than in the laboratory [11]. In our study, participants rated tofu dipped in soy sauce as less salty and firmer in the 'meat' context compared to the other contexts. The less salty taste is consistent with the inverted U-shaped liking curve, in which the salt level can be perceived as too high and is liked less than the optimum preferred salt level [12]. We think that in our case, the general salty taste of the tofu with

soy sauce was higher than optimal given the small size of the tofu blocks. From these results, it can be assumed that a restaurant-like 'meat' environment influences people's arousal and stimulates the amount consumed by affecting people's sensory perceptions. In addition, although the different contexts were labeled as 'sustainable, 'meat', and 'neutral', they differed in a number of aspects. The mood (e.g., music and theme color) in the 'sustainable' and 'neutral' environments was generally more relaxed or serene, whereas in the 'meat' environment, it was more lively and upbeat, which could be an explanation for the differences in arousal observed.

Contrary to our expectations, top-down information did not affect any rating, except for firmness. There is a possibility that the pitch was less effective at the time of soy sauce evaluation when participants were exposed to multisensory contexts, which happened about 10 min after the pitch was finished.

In the present study, we cannot disentangle the effects of the different sensory elements in the multisensory context. For future studies, it is important to obtain more insights into which and how components of multisensory contexts affect consumers' food perceptions, since this could help in increasing the affinity for plant-based and sustainable food. Also, a comparison with non-vegetarian food would help to interpret the results. A paper on this is forthcoming regarding another part of this study on meat- and plant-based hotdogs.

5. Conclusions

This out-of-the-lab study revealed that the environmental context affected evaluations of soy sauce and tofu and tends to affect the amount consumed. No effects of an informative pitch and no interaction effects of the pitch and context on food evaluation and amount consumed were observed. The multisensory context has the potential to positively affect peoples' choices and perception of plant-based and sustainable food and promote its consumption outside the lab.

Author Contributions: Conceptualization, E.v.d.B., J.B.F.v.E., A.-M.B., E.H.Z. and A.T.; methodology, H.H., E.v.d.B., I.V.S., A.T., S.V., E.H.Z., D.v.O., M.A.H., J.B.F.v.E. and A.-M.B.; software, I.V.S., S.V. and E.v.d.B.; validation, I.V.S., S.V. and E.v.d.B.; formal analysis, D.v.O. and H.H.; investigation, H.H., E.v.d.B., A.T., S.V., E.H.Z., M.A.H., J.B.F.v.E. and A.-M.B.; resources, I.V.S., H.H., E.H.Z., E.v.d.B. and A.T.; data curation, D.v.O. and H.H.; writing—original draft preparation, H.H. and A.-M.B.; writing—review and editing, H.H., E.v.d.B., I.V.S., A.T., S.V., E.H.Z., D.v.O., M.A.H., J.B.F.v.E. and A.-M.B.; visualization, H.H.; supervision, A.-M.B.; project administration, A.-M.B.; funding acquisition, E.v.d.B., J.B.F.v.E., A.-M.B., E.H.Z. and H.H. Author contributions reflect contributions to the setup of the complete Lowlands food study. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of TNO (protocol code 2021-071; date of approval 2 August 2021).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Restrictions apply to the availability of these data. Data are available from the authors with the permission of Kikkoman Europe R&D Laboratory B.V.

Conflicts of Interest: H.H. is employed by Kikkoman Europe R&D Laboratory B.V., the Netherlands, a company that markets soy sauce, soy-sauce-based seasonings and wholesale of oriental foods. E.Z. is an employee of Unilever Foods Innovation Centre Wageningen, the Netherlands, a company that markets food products. The authors E.v.d.B., I.S., A.T., S.V., D.v.O., M.A.H., J.B.F.v.E. and A.-M.B. declare no conflict of interest.

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