Estimating cross-cultural affective food experience using explicit self-report and implicit physiological measures

A thesis submitted for the degree of Master of Science in Applied Cognitive Psychology
August 20, 2019

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Abstract

Emotional attitudes toward food have recently been identified as an important factor in consumer behavior. Food-related emotions are typically measured using explicit self-report measures. However, these measures do not reliably reflect these emotions due to cultural response biases, making them less useful for cross-cultural studies. Implicit physiological methods could potentially resolve this issue as they reflect fast, non-conscious, and uncontrollable mechanisms. In this study, we compared explicit (self-report rating scales: valence, arousal, and hedonic liking) and implicit (physiological: heart rate and electrodermal activity) responses from Dutch and Thai participants towards 'universal' (molded and regular foods) and 'cultural' (Dutch and Thai foods) food pictures. The objective of the study was to investigate whether implicit physiological measures enable an objective comparison of core affective food experiences across cultures, without the cultural response biases that affect explicit measures. For both cultural groups, we expected that universal foods would elicit the same emotional responses, while cultural foods would yield a stronger affective response depending on food familiarity. We hypothesized that implicit measures would reflect the core affective response, whereas explicit measures were expected to reflect both differences in emotional experience with the food and cultural response biases (an extreme response style for Dutch participants and middle response style for Thai participants). The results for the explicit measures confirmed our hypotheses: valence and hedonic liking ratings were indeed higher for familiar than unfamiliar food pictures, while the ratings for universal pictures reflected the expected cultural response biases. The results for the implicit measures only partly confirmed our hypotheses: heart rate responses towards molded food pictures differed between cultural groups and electrodermal activity could not differentiate between the molded and regular pictures. Although there was a response pattern in the expected direction, implicit measures were only partially sensitive in differentiating between familiar and unfamiliar food pictures. In summary, we conclude that the explicit assessment of food-related emotions can indeed be culturally biased, whereas there are indications that physiological measures can provide more objective information about the experienced emotions.

1. Introduction

Emotional attitudes toward food have recently been recognized as an important factor in consumer behavior (Kaneko, Toet, Brouwer, Kallen, & Van Erp, 2018b; Prescott, 2017). Specifically, food-evoked emotions have an additional predictive value to standard hedonic scales in estimating whether consumers will choose a certain product or not (Dalenberg et al., 2014, Gutjar et al., 2015; Köster, & Mojet, 2015; Samant, Chapko, & Seo, 2017). Capturing those emotions cross-culturally is an important goal for international food marketers as food experience is determined by cultural background (Meiselman, 2013; Rozin, 1988).

Two recent literature reviews on what explicit ('conscious', self-report ratings) and implicit ('unconscious', physiological and behavioral) measures are currently used to assess food-evoked emotions both show a predominance of explicit methods in the field (Kaneko et al., 2018b; Lagast, Gellynck, Schouteten, De Herdt, & De Steur, 2017). Advantages of explicit tools are their ease of application, cost-effectiveness, and practical analyses for researchers (Dorado, Chaya, Tarrega, & Hort, 2016; Lawless, & Heymann, 2010). However, since culture affects how people use emotion language to describe their food experience and because of cultural differences in response style, usage of self-report methods to assess affective experiences cross-culturally is problematic (Ares, 2018; van Zyl, & Meiselman, 2015 and 2016). Response style can be described as a respondent's tendency to rate items in a systematic manner irrespective of the question's content (Baumgartner, & Steenkamp, 2001). The extreme response style (tendency to answer using the end-points of rating scales) is typically associated with Europeans and Americans, whereas Asian respondents more often use a middle response style (tendency to answer using the neutral response categories) (Chen, Lee, & Stevenson, 1995; Harzing, 2006; Kaneko et al., 2018c). We could potentially circumvent these issues by using implicit methods that reflect fast, non-conscious, and uncontrollable mechanisms (Ares, 2018; Kaneko et al., 2018b; Lagast et al., 2017). Several studies suggest that no difference between cultural groups exist in physiological responses to stimuli such as acoustic startle (Soto, Levenson, & Ebling, 2005), emotional films (Tsai, Levenson, & Carstensen, 2000), and reliving of intense emotional episodes (Tsai, Chentsova-Dutton, Freire-Bebeau, & Przymus, 2002). We found one study that does show weaker electrodermal responses to disgust-eliciting film clips in Asian- compared to European-Americans (Soto, Lee, & Roberts, 2016). This was taken to indicate that in Eastern cultures, emotion suppression is seen as desirable, i.e., the different pattern may reflect an actual difference in experienced emotion and furthermore shows the suitability of physiological measures to detect emotional differences.

Core affect is a consciously accessible neurophysiological state resulting from a combination of two feeling continuums: valence (pleasant to unpleasant) and arousal (low to high activation) (Russell, 1980; Schutz, Quijada, de Vries, & Lynde, 2007). Valence is an important determinant in food liking but may be considered of limited value in consumer research when measured on its own, as most products elicit equally high liking scores within their food category (Beyts et al., 2017; He, de Wijk, De Graaf, & Boesveldt, 2016). Arousal has received relatively less attention in emotional food research, but this may be undeserved. Arousal affects the memorability of an event (Anderson, Wais, & Gabrieli, 2006; McGaugh, 2006) where an adequate level of arousal is required for a product to be remembered and eaten again in the future (Köster, & Mojet, 2006). Unlike older motivation theories which were based on the notion that behavior is driven by need-reduction (hunger leads to eating which leads to satiation), current motivation theories support the viewpoint that organisms are driven by exploratory behavior to maintain an optimal level of activation (Köster, & Mojet, 2006). Although the exact mechanism between physiological arousal and product liking remains undiscovered, the optimal level of arousal theory (Berlyne, 1967; Hebb, 1946, 1949, 1958; Zukerman, 1969) suggests that (next to a general liking of the food) the attractiveness of stimuli depends on their arousing properties (e.g. intensity, complexity, novelty) in relation to the individual's optimal arousal level (Köster, & Mojet, 2006 and 2015). Measuring arousal is therefore an interesting aspect of food experience and an important factor to consider in food affective research. Physiological measurement methods reflect Autonomic Nervous System (ANS) activity and are more suitable to assess arousal than to measure valence (Kreibig, 2010; Mendes, 2009).

Several physiological measures have been studied in the context of probing affective experience in response to tasting and viewing food (pictures). Electrodermal activity (EDA) and heart rate (HR) are the most often used implicit measures in recent consumer research and have shown sensitive in distinguishing between tasting beverages, juices, chocolates, liked and disliked food (Brouwer et al., submitted manuscript 2018; Danner, Haindl, Joechl, & Duerrschmid, 2014; de Wijk, Kooijman, Verhoeven, Holthuysen, & De Graaf, 2012; Torrico et al., 2018b). Numerous studies indicate that pictures of food also elicit ANS responses and activate gustatory processing areas in the brain, which suggests that pictures are eligible replacements for real food stimuli (Kuoppa et al., 2016; Simmons, Martin, & Barsalou, 2005; Tang, Fellows, Small, & Dagher, 2012; van der Laan, De Ridder, Viergever, & Smeets, 2011). Physiological measurements furthermore differentiate between familiar and unfamiliar stimuli. The orienting reflex is an evolutionary sympathetic-parasympathetic response to novel stimuli in which attention is directed to an unexpected stimulus to determine if further processing and adaptive action are required (Campbell, Wood, & McBride, 1997; Ellsworth, & Scherer, 2003). The response has been found for tasting liquids and is typically associated with increases in EDA and decreases in HR (Bradley, 2009; Verastegui-Tena, van Trijp, & Piqueras-Fiszman, 2018).

The objective of this study is to investigate whether implicit physiological (electrodermal activity and heart rate) measures can contribute in comparing affective food experiences across cultures objectively, without the cultural response biases that affect explicit self-report methods. To the best of our knowledge, there are only two cross-cultural studies in the food domain which also focused on implicit methods (Torrico, Fuentes, Viejo, Ashman, & Dunshea, 2018a; Torrico et al., 2018b). These studies used rating scales and a camera to monitor heart rate, skin temperature, and facial expressions to investigate cross-cultural effects (Asian vs. American) on images and chocolates (Torrico et al., 2018b) and on food product familiarity and sensory acceptability (Torrico et al., 2018a). Results suggest that food liking is positively correlated to familiarity (Torrico et al., 2018a), that only skin temperature differentiates between cultural groups when tasting culture-specific food samples (Torrico et al., 2018a), and that no physiological differences between cultural groups exist when tasting (universal) chocolate samples (Torrico et al., 2018b). These results are in line with the idea that physiological measures reflect the 'true' emotion: cultural groups do not differ when tasting universal stimuli and they do differ (in skin temperature) when tasting samples that are expected to 'really' elicit different emotions. However, camera-based analysis is less precise and subject to artifacts like (chewing) movements, head orientation, and lighting conditions (Bach, Stewart, Minett, & Costello, 2015; Hassan et al., 2017; Kranjec, Beguš, Geršak, & Drnovšek, 2014). In our study we follow a similar rationale, using more robust conservative contact-based assessments, and more carefully comparing results to possible response biases in different types of explicit measures.

In this study, we will compare explicit and implicit responses from two cultural participant groups, Dutch and Thai, towards food pictures. Participants' physiological responses (implicit measures) are measured during the experiment and they rate their emotional response and liking (explicit measures) towards each picture. The food pictures portray universal molded and regular foods (considered familiar to everyone), and typically Dutch and Thai foods. We selected a universal and cultural stimulus set so that we can assume genuine (stronger) differences in emotional experience between Dutch and Thai individuals for cultural foods, but no (or weaker) differences for universal foods. Molded food pictures are assumed to elicit low valence and high arousal responses, whereas for regular food pictures higher valence and moderate arousal responses are expected. Responses towards Dutch and Thai food pictures are assumed to depend on the individual's familiarity level with the food. For the cultural stimulus set (Dutch and Thai food pictures), we expect response differences between Dutch and Thai participants on both explicit and implicit measures. More specifically, we expect that (H1) explicit measures are culturally determined in two ways: through the genuine differences in emotional experience with the food and through cultural response biases. Secondly, we hypothesize that (H2) implicit physiological measures merely reflect differences in core affective experience between Dutch and Thai participants without being affected by cultural response biases. For the universal stimulus set (molded and regular food pictures), we expect that (H3) explicit responses differ between cultural groups due to cultural response biases. More specifically, we expect Dutch participants to use an extreme response style and Thai participants to use a middle response style. Lastly, we hypothesize that (H4) implicit physiological responses towards universal food pictures are culturally invariant, as the food is assumed to be similarly familiar to both participant groups and biological responding is similar, while there will be no influence of cultural response biases.

2. Methods

2.1. Participants

In this study, we tested groups of participants from Thailand and The Netherlands. To maximize the likelihood that response differences between participants resulted from cultural differences in their food experience, we excluded people with color vision deficiencies; food allergies; diets such as vegetarian, vegan or religion-related diet; an immigration background; an eating disorder diagnosed in the last three years; who had visited The Netherlands (for Thai participants) or Thailand (for Dutch participants); and who had lived abroad for more than one month. Forty-two Thai participants were recruited from Chulalongkorn University Thailand and forty-five Dutch participants were recruited from the participant pool of the research institute where the main part of the research was conducted (TNO Soesterberg, The Netherlands). Because internal state influences responses to food pictures, participants were asked to not eat for 1 hour before testing (Drobes et al., 2001). The experimental protocol was approved by the TNO Institutional Review Board (Ethical Approval Ref: 2019-033) and was in accordance with the revised Helsinki Declaration (World Medical Association, 2013). All participants signed an informed consent sheet before the experiment started and received a reward to thank them for participating in the study.

2.2. Materials

2.2.1. Food pictures

Food pictures were selected from the Cross Cultural Food Image Database (CROCUFID) (Toet et al., 2019). The CROCUFID is a collection of food and non-food pictures, photographed on a standardized plate using a standardized photographing protocol (Charbonnier, Van Meer, Van der Laan, Viergever, & Smeets, 2016). Two stimulus sets were selected from this database: a 'universal' set of 60 food pictures portraying molded and regular foods (considered familiar to everyone) and a 'cultural' set of 60 food pictures portraying typically Dutch and Thai foods. The universal stimulus set was chosen in such a way that the pictures covered a wide scale of valence and arousal with 13 molded and 47 regular food pictures. The cultural stimulus set consisted of 30 typically Dutch and 30 typically Thai food pictures. To ensure participants

Figure 1. Stimulus examples of (A) universal molded food pictures (melon and strawberries) and regular food pictures (cucumber and French fries), (B) Dutch food pictures (herring, wheat bread, liquorice candy, stroopwafels), and (C) Thai food pictures (dragon fruit, seaweed chips, som tam, grass jelly).

interpreted the food similarly, the national flag of the food's origin was presented on the right bottom of every picture. Universal dishes were accompanied by a picture of a globe. Stimulus examples are shown in Figure 1. To test our assumption of culturally dependent familiarity of the stimuli, and to identify possible participants who did not meet the assumption of a much stronger familiarity to the type of food of the own cultural group, participants rated their degree of familiarity with all foods at the end of the experiment. Anchors of this five-point scale were labeled: 1) "I do not recognize it", 2) "I recognize it, but I have not tasted it", 3) "I have tasted it", 4) "I occasionally eat it", 5) "I regularly eat it" (adapted from Tuorila, Lähteenmäki, Pohjalainen, and Lotti, 2001). Participants were verbally explained that the scale was intended to measure familiarity from 1 to 5, rather than that we were interested in the exact frequency of eating the food. To increase engagement with the pictures, participants were told they would taste some of the depicted food. This part of the instruction was formulated in such a way that the participants were led to believe that they could be asked to eat an unpleasant (molded) food item *("There are four short breaks in this session. During these breaks, we will serve you one of the foods depicted in the pictures that you just saw. We ask you to taste this food. You are permitted to refuse, but we hope you will taste it. All served food has been declared safe to taste by a medical doctor.")*. Tasting breaks were introduced after each half block (30 pictures) and tasting samples were banana pieces, peanut chocolate candies, half a seaweed chip, and a small 'stroopwafel' (typically Dutch cookie).

2.2.2. Apparatus

The electrocardiogram (ECG) and EDA were recorded via a Biosemi Active Two MkII system (https://www.biosemi.com/products.htm) with a sampling frequency of 512 Hz. EDA was measured by placing gelled electrodes on the fingertips of the index and middle finger of the non-dominant hand. ECG electrodes were placed on the lowest floating left rib and the right clavicle. Two ground electrodes were placed on the temporal bones behind the ears. The experiment was programmed in Inquisit 4 (2015) and presented on a Dell Latitude E6320 notebook with a LED-screen (1366×768 pixels).

2.2.3. Self-report rating scales

Participants judged affective experience and liking of each picture by clicking appropriate locations in the Cartesian valence-arousal EmojiGrid (shown in Figure 2) (Toet et al., 2018) and using a traditional nine-point hedonic scale (Peryam, & Pilgrim, 1957). The EmojiGrid is an intuitive visual self-report tool that has been specifically developed for the assessment of food-evoked emotions and has shown to be suitable for cross-cultural testing (Kaneko et al., 2018c; Toet et al., 2018). The nine-point hedonic scale is the most commonly used scale for testing consumer preference and acceptability of foods. The anchors are: 1) "dislike extremely", 2) "dislike very much", 3) "dislike moderately", 4) "dislike slightly", 5) "neither like nor dislike", 6) "like slightly", 7) "like moderately", 8) "like very much", and 9) "like extremely" (Lim, 2011). Since appreciation of food images is known to be influenced by Body Mass Index (BMI), a demographic questionnaire including questions about body height and weight, as well as age and gender was presented at the end of the experiment (Burger, Cornier, Ingebrigtsen, & Johnson, 2011).

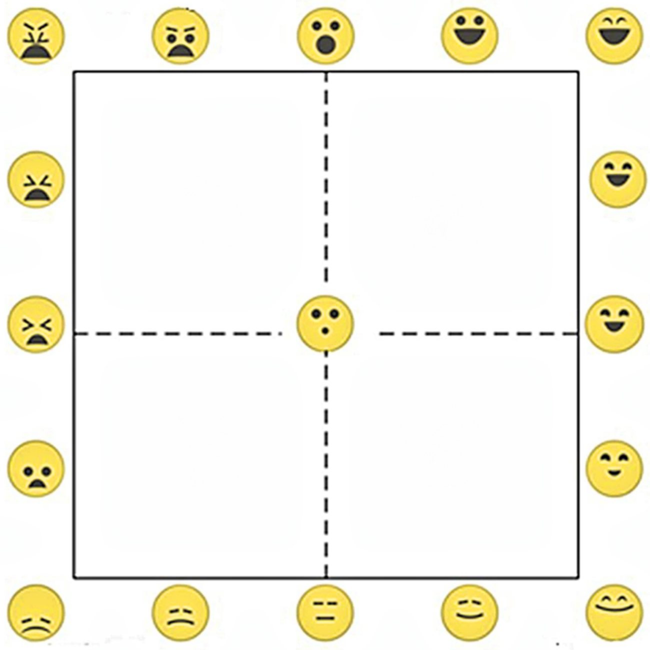

Figure 2. The EmojiGrid is a self-report tool designed for investigating food affective experience. Valence is represented on the x-axis and ranges from disliking to liking (from left to right). Arousal is displayed on the y-axis and varies from calm to aroused (from bottom to top) (Kaneko et al., 2018c).

2.3. Procedure and design

After participants arrived at the laboratory, the experimental procedure was explained, and they signed an informed consent form. The EDA, ECG, and ground electrodes were attached and all signals were checked, after which the participant was seated in a comfortable chair behind the presentation notebook. Participants first performed a short session in which they tasted and rated water, and a typically Dutch and Thai drink (data not analyzed here)[1]. After a short break, participants started the session with the food pictures. They viewed a total of 120 food pictures in two counterbalanced blocks (a universal and cultural block) each consisting of 60 randomized pictures. A fixation cross was presented for 1 s, after which the food picture was presented. After 10 s of viewing time, the EmojiGrid and hedonic scale appeared in successive, randomized order. Participants had unlimited time to provide their rating using the mouse but were instructed to give their initial response. One of the viewed food items was served to participants after every 30 images during a short break. Figure 3 schematically depicts an experiment trial. Participants rated their familiarity with all foods after tasting the drinks and viewing of pictures was finished. Lastly, they filled out the short demographic questionnaire. The total duration of the experiment was approximately 75 minutes.

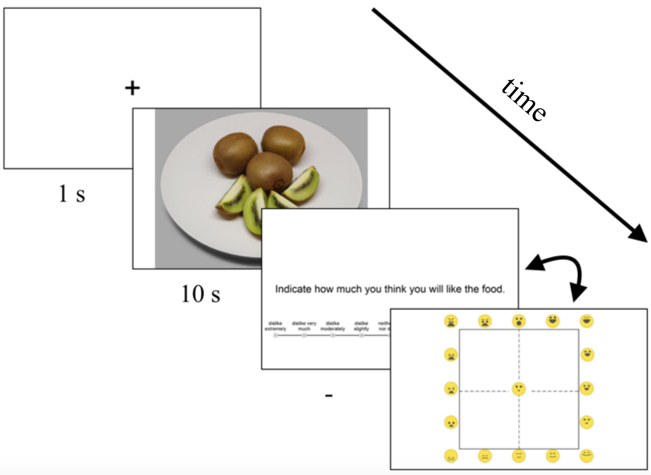

Figure 3. Procedural overview of one trial for viewing a food picture. Presentation of the self-report rating scales (EmojiGrid and hedonic scale) was randomized.

2.4. Data processing and analyses

Data were examined for indications of participants not adhering to the rating task (e.g. no variations in answers) and possible measurement errors. We found no suspicious EmojiGrid and hedonic scale response patterns. Three Thai participants were excluded from physiological EDA and HR data analyses as a result of faulty measurements due to detached electrodes during the experiment. Physiological data were further inspected for outliers using a liberal criterion of 5 standard deviations from the mean. This resulted in removal of 0.52% of the raw EDA data.

2.4.1. Continuous response traces

Inter-beat interval (IBI) time series, defined as the temporal distance between R-spikes (Appelhans, & Luecken, 2006), were extracted from the ECG signal and converted to HR per second. The EDA signal was split into tonic (overall skin conductance level) and phasic (skin conductance response) components using the Ledalab toolbox (Benedek, & Kaernbach, 2010). The more meaningful phasic component in the electrical conductivity of the skin (Braithwaite, Watson, Jones, & Rowe, 2013) was used for further analysis. Physiological traces were shifted to all start at zero (baselined using the HR or EDA value at the time of the fixation cross). The values of each 10 s viewing time trace were averaged for statistical analysis.

2.4.2. Variables

For analysis of the universal stimulus set, responses from each participant for the 60 universal food pictures were averaged across the molded food (13 pictures) and regular food (47 pictures) picture sub-type. Regarding analysis for the cultural stimulus set, responses from the 60 cultural food pictures were averaged across the Dutch food (30 pictures) and Thai food (30 pictures) picture sub-type per participant. This was done for each of the six dependent variables: EmojiGrid valence scores, EmojiGrid arousal scores, hedonic liking scores, familiarity scores, HR, and EDA.

[1] The protocol for this part of the study was similar to that described in Kaneko et al. (submitted manuscript 2018a). Participants rated their emotional response and liking towards each drink using the EmojiGrid and hedonic scale in randomized, successive order. EDA and HR were measured during this part of the study as well.

2.4.3. Statistical analyses

Firstly, a mixed ANOVA was performed to test whether our manipulation of (un)familiarity with the food pictures worked with within-subject factor picture sub-type (Dutch, Thai, and universal regular food pictures) and between-subject factor cultural participant group (Dutch, Thai) for the dependent variable familiarity scores. For the cultural stimulus set, mixed ANOVAs were performed to test for an effect of the within-subject factor picture sub-type (Dutch food pictures, Thai food pictures) and the between-subject factor cultural participant group (Dutch, Thai) for each dependent variable except familiarity scores. Concerning the universal stimulus set, mixed ANOVAs were performed to test for an effect of the within-subject factor picture sub-type (molded food pictures, regular food pictures) and the between-subject factor cultural participant group (Dutch, Thai) for each dependent variable except familiarity scores.

3. Results

3.1. Demographics

Table 1 displays the demographic descriptives for Dutch and Thai participants. No significant differences were found between cultural participant groups for the gender ratio and BMI when using a Pearson's chi-square test of contingencies and Mann Whitney *U* test respectively. A Mann Whitney *U* test with dependent variable age and independent variable cultural participant group (Dutch, Thai) indicated that Dutch participants (*Mean Rank* = 49.01, n = 45) were significantly older than Thai participants (*Mean Rank* = 38.63, $n = 42$), with $U = 719.50$, $z = -1.96$, $p = .05$. Note that even though the difference is significant, it is small (less than a year in age). For the properties tested, we consider the groups to be similar.

Table 1. *Demographic variables for the Dutch and Thai participants.*

Cultural group	N	Female	Male	Age	BMI
Dutch	45	28	17	21.2	22.29
Thai	42	24	18	20.6	21.58

3.2. Participant's familiarity with the food pictures

To test whether our manipulation of culturally dependent familiarity of the food pictures worked out as expected with each cultural group being more familiar to food from the own culture and both groups being about equally familiar with universal foods, a mixed ANOVA was performed on familiarity scores, with within-subject factor picture sub-type (Dutch, Thai, regular universal food pictures) and between-subject factor cultural participant group (Dutch, Thai). The familiarity scores for the universal molded food pictures were excluded from analysis because familiarity was considered ambiguous to rate. The assumptions of normality and equality of error variances were violated in this test. However, the *F*-ratio is generally considered robust against assumption violations when sample sizes are moderate to large (N > 30) and are equal in size. The test showed significant main effects for picture sub-type (F (2, 170) = 340.49, $p < .001$, partial $\eta^2 = .80$) and cultural group (F (1, 85) = 15.01, $p < .001$, partial $\eta^2 = .15$). A significant picture sub-type×cultural group interaction effect was found as well with F (2, 170) = 842.70, $p < .001$, and partial $\eta^2 = .91$. Post hoc tests using Bonferroni correction indicated that participants were indeed more familiar with the food pictures portraying food from their own culture's cuisine and showed higher familiarity ratings in Dutch participants towards universal food than in Thai participants.

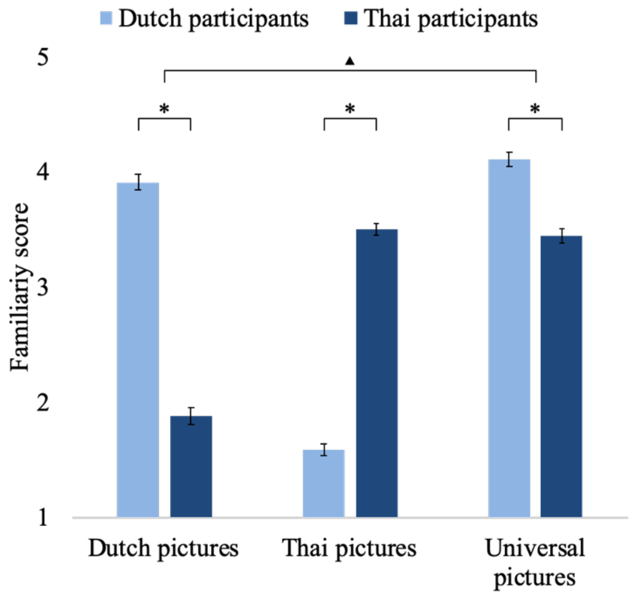

Figure 4. Familiarity rating scores for Dutch, Thai, and universal regular food pictures. Error bars represent the standard error of the mean.
▲ = main effect and * = interaction effect

Familiarity ratings averaged across cultural participant group and picture sub-type are presented in Figure 4. Descriptive statistics and pairwise comparisons can be found in Table 1 and 2 in Appendix A.

3.3. Explicit and implicit responses towards Dutch and Thai (cultural) food pictures

This section focuses on the results regarding H1: explicit self-report measures are affected by genuine differences in emotional experience with the food and through cultural response biases and H2: implicit physiological measures merely reflect differences in core affective experience between Dutch and Thai participants without being affected by cultural response biases. Mixed ANOVAs with within-subject factor picture sub-type (Dutch food pictures, Thai food pictures) and between-subject factor cultural participant group (Dutch, Thai) were performed for the dependent variables EmojiGrid valence scores, EmojiGrid arousal scores, hedonic liking scores, HR, and EDA.

3.3.1. H1: Explicit responses concerning the EmojiGrid valence scores, EmojiGrid arousal scores, and hedonic liking scores towards Dutch and Thai food pictures

The EmojiGrid mean valence and arousal scores for Dutch and Thai food pictures are shown in Figure 5 and 6 respectively. Each data point represents the averaged ratings for one food picture from Dutch and Thai participants. Differences in response style between cultural groups can already be observed from these figures. It can be noted that one Thai food picture (chicken feet) elicited remarkably unpleasant and highly arousing responses in Dutch participants. Exclusion of this picture from the analysis does not influence the interpretation of the results presented below.

Analysis concerning the EmojiGrid valence scores revealed significant main effects for picture sub-type (F (1, 85) = 22.82, p < .001, partial η^2 = .21) and cultural group (F (1, 85) = 4.71, p = 0.033, partial η^2 = .05). A significant picture sub-type × cultural group interaction effect with F (1, 85) = 129.02, p < .001, partial η^2 = .61 was found as well. Post hoc analysis using Bonferroni correction revealed that cultural groups differed in their responding towards both the Dutch and Thai pictures. Investigation of the means revealed that participants rated the familiar food pictures (Dutch pictures for Dutch participants and Thai pictures for Thai participants) higher in valence than unfamiliar pictures (Thai pictures for Dutch participants and Dutch pictures for Thai participants), as can be seen in Figure 7. Descriptive statistics and pairwise comparisons can be found in Table 3 and 4 in Appendix A.

The EmojiGrid arousal scores obtained a significant main effect for cultural group with F (1, 85) = 7.06, p = 0.009, partial η^2 = .08, and a significant picture sub-type × cultural group interaction effect with

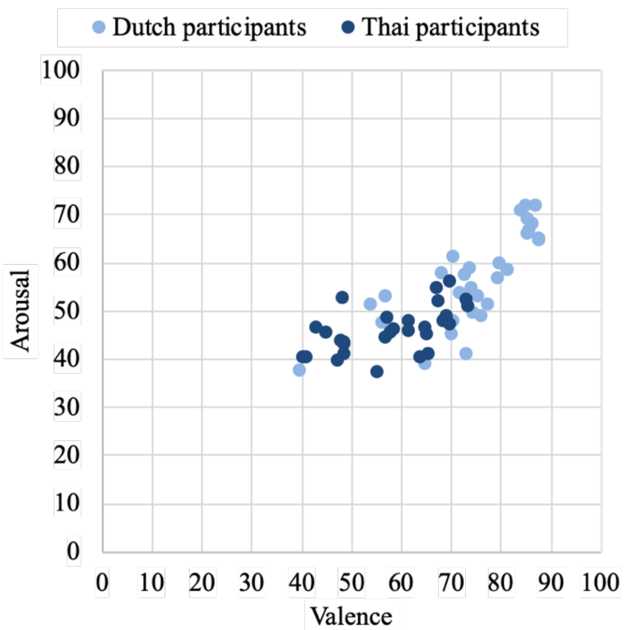

Figure 5. EmojiGrid mean valence (x-axis) and arousal (y-axis) scores for Dutch food pictures. Each data point represents the averaged ratings from Dutch and Thai participants for one picture.

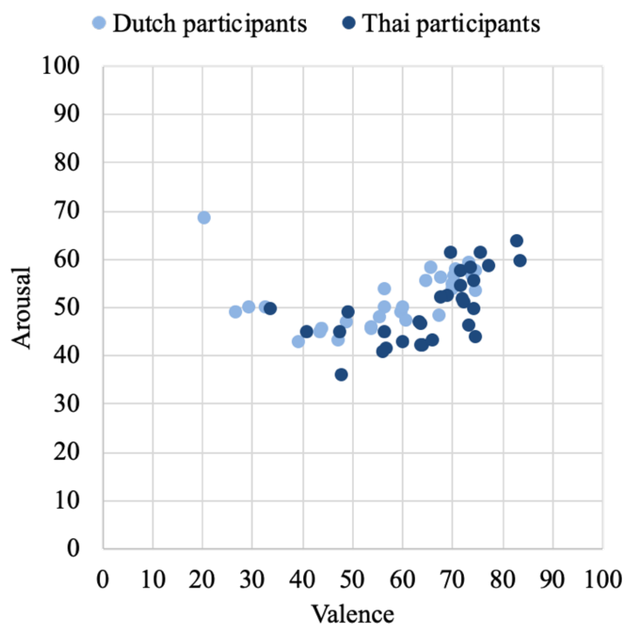

Figure 6. EmojiGrid mean valence (x-axis) and arousal (y-axis) scores for Thai food pictures. Each data point represents the averaged ratings from Dutch and Thai participants for one picture.

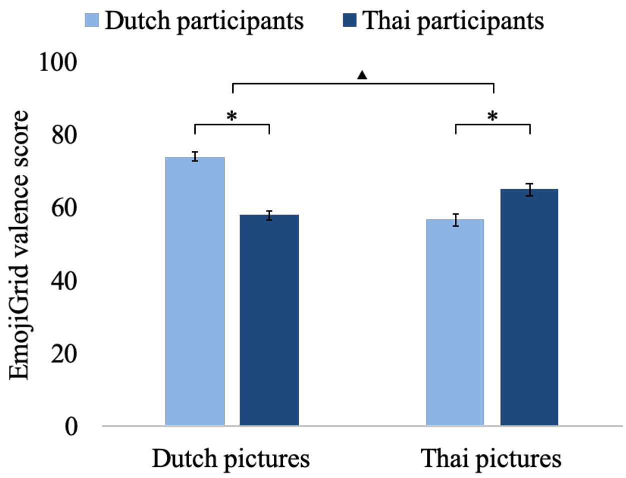

Figure 7. EmojiGrid valence scores towards Dutch and Thai (cultural) food pictures. Error bars represent the standard error of the mean.
▲ = main effect and * = interaction effect

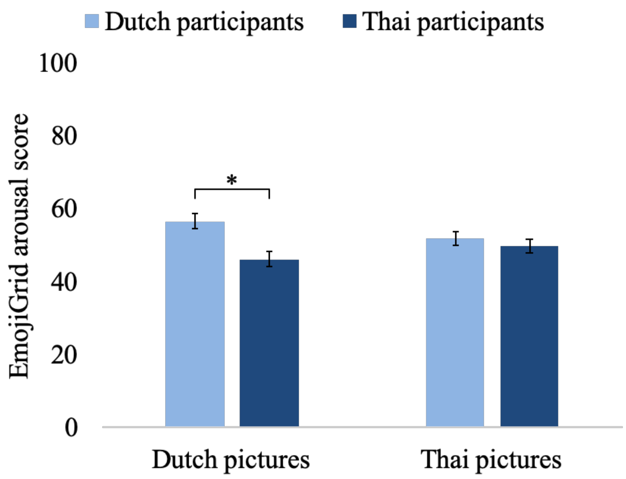

Figure 8. EmojiGrid arousal scores towards Dutch and Thai (cultural) food pictures. Error bars represent the standard error of the mean.
* = interaction effect

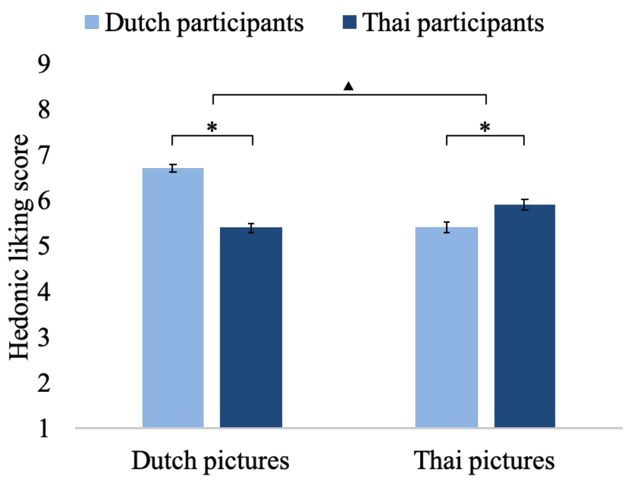

Figure 9. Hedonic liking scores towards Dutch and Thai (cultural) food pictures. Error bars represent the standard error of the mean.
▲ = main effect and * = interaction effect

F (1, 85) = 8.231, p = 0.005, partial η^2 = .09. The main effect of picture sub-type was not significant. Post hoc analysis using Bonferroni correction revealed that cultural groups differed in their responding towards the Dutch food pictures. Dutch participants rated those pictures as more arousing than Thai participants. Figure 8 shows the EmojiGrid arousal scores averaged across cultural participant group and picture sub-type. Descriptive statistics and pairwise comparisons can be found in Table 5 and 6 in Appendix A.

Analysis concerning the hedonic liking scores revealed significant main effects for picture sub-type (F (1, 85) = 21.75, p < .001, partial η^2 = .20) and cultural group (F (1, 85) = 11.98, p = 0.001, partial η^2 = .12). A significant picture sub-type×cultural group interaction effect was obtained as well with F (1, 85) = 119.71, p < .001, partial η^2 = .21. Post hoc analysis using Bonferroni correction revealed that cultural groups differed in their responding towards both the Dutch and Thai pictures. Investigation of the means revealed that participants rated the familiar food pictures higher in valence than unfamiliar pictures, which is consistent with the EmojiGrid valence scores. The assumption of equal error variances was violated in this test. Hedonic scores averaged across cultural participant group and picture sub-type are presented in Figure 9. Descriptive statistics and pairwise comparisons can be found in Table 7 and 8 in Appendix A.

3.3.2. H2: Implicit responses concerning heart rate and electrodermal activity towards Dutch and Thai food pictures

Analysis concerning HR responses revealed significant main effects for picture sub-type (F (1, 82 = 4.62, p = 0.035, partial η^2 = .05) and cultural group (F (1, 82) = 6.98, p = 0.010, partial η^2 = .08). A significant picture sub-type×cultural group interaction effect was found as well, with F (1, 82) = 9.69, p = 0.003, partial η^2 = .11. Post hoc analysis using Bonferroni correction revealed that cultural groups only differed in their physiological responding towards Thai food pictures. Dutch participants had a larger decrease in HR towards these pictures than Thai participants, as can be seen in Figure 10. The assumption of homogeneity of variances was violated for this test. Descriptive statistics and pairwise comparisons can be found in Table 9 and 10 in Appendix A.

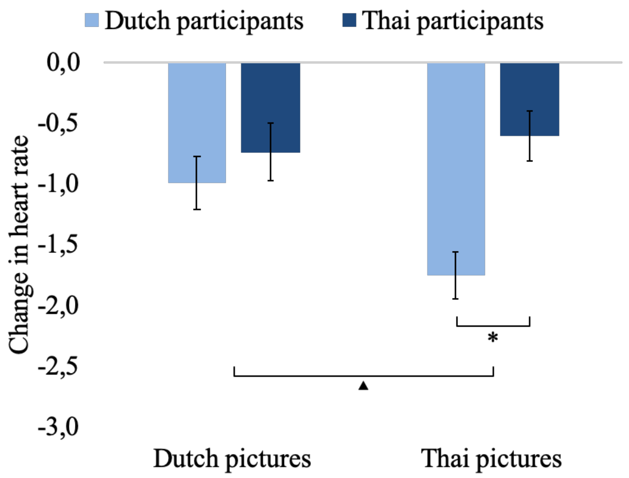

Figure 10. Relative change in heart rate averaged over the 10 s picture viewing time towards Dutch and Thai (cultural) food pictures baselined using the heart rate value at the time of the fixation cross. Error bars represent the standard error of the mean.
▲ = main effect and * = interaction effect

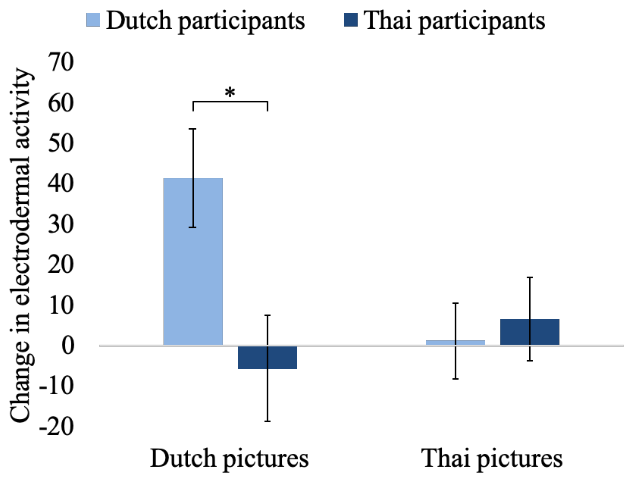

Figure 11. Relative change in electrodermal activity averaged over the 10 s picture viewing time towards Dutch and Thai (cultural) food pictures baselined using the electrodermal activity value at the time of the fixation cross. Error bars represent the standard error of the mean. * = interaction effect

EDA obtained a significant picture sub-type × cultural group interaction effect with F (1, 82) = 9.50, p = 0.003, partial η^2 = .10. The main effects of picture sub-type and cultural group were not significant. Post hoc analysis using Bonferroni correction this time revealed that cultural groups only differed in their physiological responding towards Dutch food pictures. Dutch participants had a larger EDA increase towards these pictures compared to Thai participants. The assumption of normality was violated for this test. EDA values averaged across cultural group and picture sub-type are presented in Figure 11. Descriptive statistics and pairwise comparisons can be found in Table 11 and 12 in Appendix A.

Additional testing using α = 0.025 revealed that Thai participants did not react differently upon viewing Dutch or Thai food pictures for both HR and EDA, while Dutch participants did for HR (t = 2.28, p = 0.020) but not EDA. The independent samples t-tests and Mann Whitney U tests for HR and EDA can be found in Table 13 and 14 in Appendix A respectively.

3.4. Explicit and implicit responses towards molded and regular (universal) food pictures

This section focuses on the results regarding H3: explicit responses differ between cultural groups due to cultural response biases (Dutch participants will use an extreme response style and Thai participants a middle response style) and H4: implicit responses towards universal food pictures are culturally invariant as the food is assumed to be similarly familiar to both participant groups and biological responding is similar, while there will be no influence of cultural response biases. Mixed ANOVAs with within-subject factor picture sub-type (molded food pictures, regular food pictures) and between-subject factor cultural participant group (Dutch, Thai) were performed for the dependent variables EmojiGrid valence scores, EmojiGrid arousal scores, hedonic liking scores, HR, and EDA. The assumptions of normality and equality of error variances were violated for the tests concerning the EmojiGrid valence scores, hedonic liking scores, and HR values.

3.4.1. H3: Explicit responses concerning the EmojiGrid valence scores, EmojiGrid arousal scores, and hedonic liking scores towards molded and regular food pictures

The EmojiGrid mean valence and arousal scores for molded and regular universal food pictures are presented in Figure 12. Each data point represents the averaged ratings for one food picture from Dutch and Thai participants. It can be observed that the typical U-shape between arousal and valence was replicated in our study and that there are differences in response style between the cultural groups.

Analysis for the EmojiGrid valence scores revealed significant main effects for picture sub-type (F (1, 85) = 2583.37, p < .001, partial η^2 = .97) and cultural group (F (1, 85) = 9.10, p = .003, partial η^2 = .01). A significant picture sub-type × cultural group interaction effect was

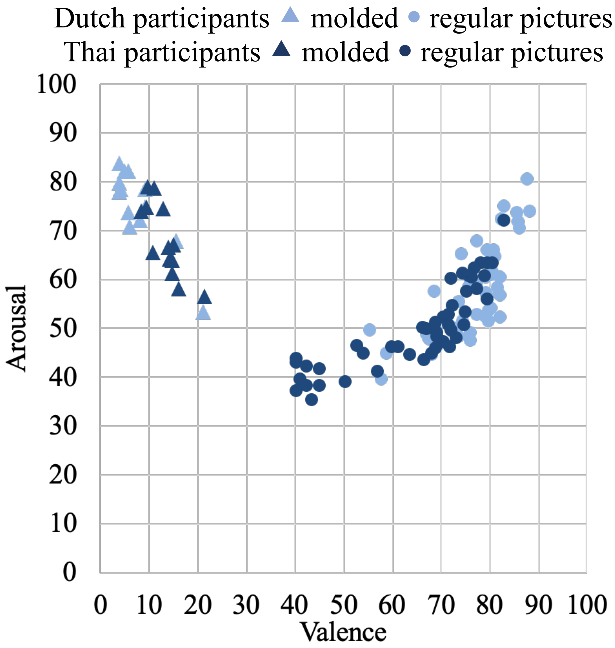

Figure 12. EmojiGrid mean valence (x-axis) and arousal (y-axis) scores for molded (▲) and regular (●) (universal) food pictures. Each data point represents the averaged ratings from Dutch and Thai participants for one picture.

obtained as well, with F (1, 85) = 51.322, p < .001, partial η^2 = .38. Post hoc analysis using Bonferroni correction revealed that cultural groups differed in responding towards both the molded and regular pictures. Dutch participants used a more extreme response style, i.e. they rated the molded food pictures more negative and the regular pictures more positive compared to Thai participants. EmojiGrid valence scores averaged across cultural participant group and picture sub-type are shown in Figure 13. Descriptive statistics and pairwise comparisons can be found in Table 15 and 16 in Appendix A.

Results from the analysis concerning EmojiGrid arousal scores showed significant main effects for picture sub-type with F (1, 85) = 61.33, p < .001, partial η^2 = .42, and cultural group with F (1, 85) = 8.89, p = .004, partial η^2 = .10. No significant interaction effect was found. Investigation of the means revealed that consistent with our expectation, the molded food pictures were rated as more arousing (M = 71.71, SD = 19.11) than regular pictures (M = 54.05, SD = 11.44). Furthermore, Dutch participants (M = 66.29, SD = 17.59) rated the pictures as more arousing than Thai participants (M = 59.59, SD = 17.98). The assumption of normality was violated for this test. Figure 14 shows the EmojiGrid arousal scores averaged across cultural

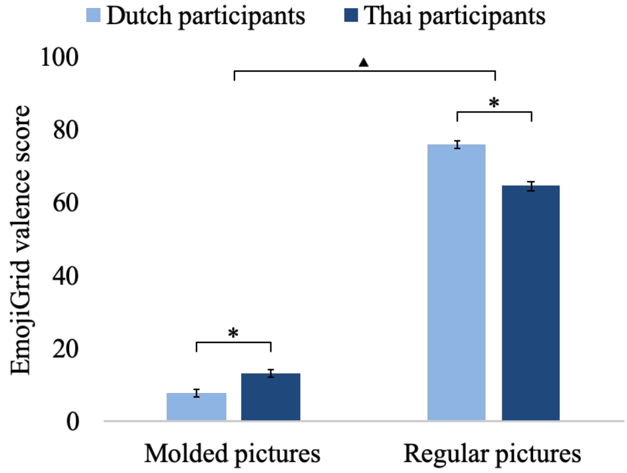

Figure 13. EmojiGrid valence scores towards molded and regular (universal) food pictures. Error bars represent the standard error of the mean.
▲ = main effect and * = interaction effect

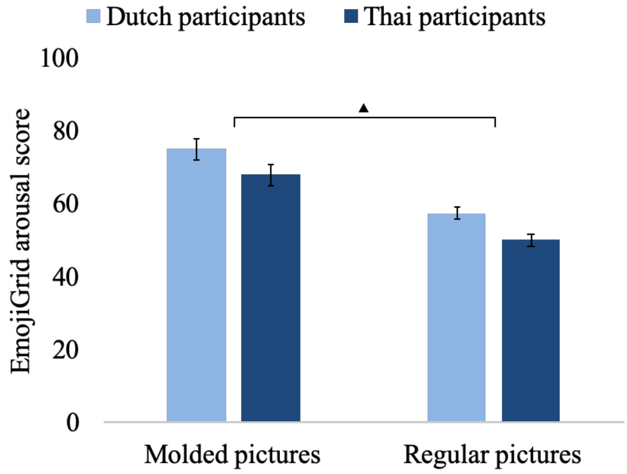

Figure 14. EmojiGrid arousal scores towards molded and regular (universal) food pictures. Error bars represent the standard error of the mean.
▲ = main effect

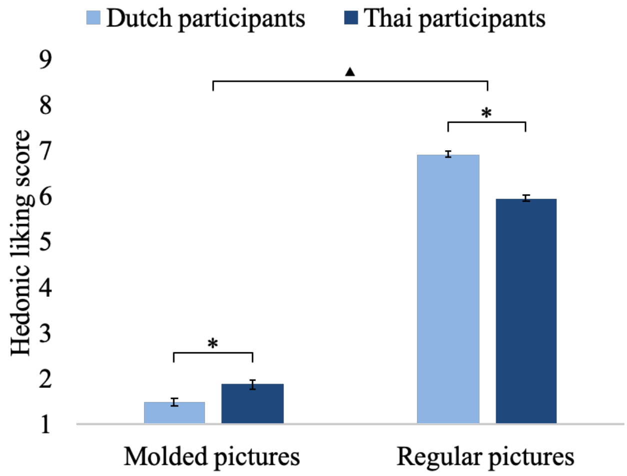

Figure 15. Hedonic liking scores towards molded and regular (universal) food pictures. Error bars represent the standard error of the mean.
▲ = main effect and * = interaction effect

participant group and picture sub-type. Descriptive statistics and pairwise comparisons can be found in Table 17 and 18 in Appendix A.

Analysis for the hedonic liking scores obtained significant main effects for picture sub-type (F (1, 85) = 3152.01, p < .001, partial η^2 = .97) and cultural group (F (1, 85) = 11.45, p = .001, partial η^2 = .12). A significant picture sub-type×cultural group interaction effect was found as well, with F (1, 85) = 63.78, p < .001, partial η^2 = .43. Post hoc analysis using Bonferroni correction revealed that cultural groups differed in their responding towards both the molded and regular pictures. Investigation of the means revealed the same response pattern as EmojiGrid valence scores; Dutch participants used an extreme response style in which they rated molded food pictures as more negative and regular pictures as more positive than Thai participants, who used a more middle response style. Figure 15 shows the hedonic liking scores averaged across cultural participant group and picture sub-type. Descriptive statistics and pairwise comparisons can be found in Table 19 and 20 in Appendix A.

Due to a large number of assumption violations, analysis for these three variables was conducted once more using logarithmically transformed data. The main effect of cultural group for hedonic liking scores became nonsignificant, but the interpretation of the results was not affected.

3.4.2. H4: Implicit responses concerning heart rate and electrodermal activity towards molded and regular food pictures

Analysis for HR responses obtained a significant main effect for picture sub-type (F (1, 82) = 24.44, p < .001, partial η^2 = .23). Unexpectedly, a main effect for cultural group with F (1, 82) = 17.53, p < .001, partial η^2 = .18 and significant picture sub-type×cultural group interaction effect with F (1, 82) = 21.66, p < .001, partial η^2 = .21, was obtained as well. Post hoc analysis using Bonferroni correction that cultural groups only differed in their physiological responding towards the molded food pictures; towards which Dutch participants had a larger HR decrease than Thai participants. Additional t-testing using α = 0.025 revealed that Thai participants did not react differently upon viewing molded or regular food pictures, while Dutch participants did (t = -4.89, p < .001). HR values averaged across cultural group and

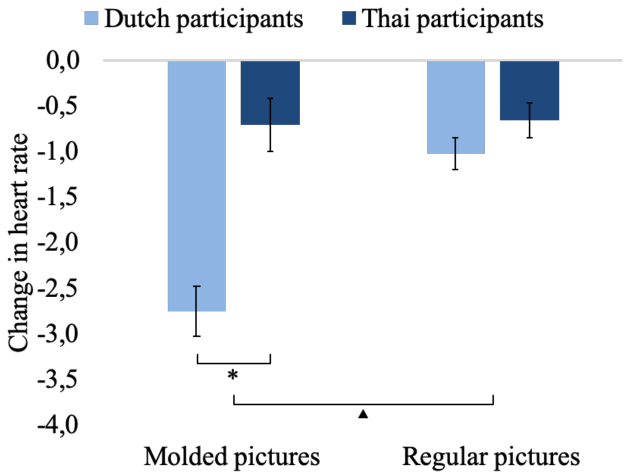

Figure 16. Relative change in heart rate averaged over the 10 s picture viewing time towards molded and regular (universal) food pictures baselined using the heart rate value at the time of the fixation cross. Error bars represent the standard error of the mean. ▲ = main effect and * = interaction effect

picture sub-type are presented in Figure 16. Descriptive statistics, pairwise comparisons, and results from the independent samples t-tests can be found in Table 21, 22, and 23 in Appendix A.

Analysis concerning EDA revealed some contradictory results. No significant main effects nor significant picture sub-type×cultural group interaction effect was found. The assumption of normality was violated for this test. Descriptive statistics and results from the mixed model ANOVA can be found in Table 24 and 25 in Appendix A.

3.5. Comparison of absolute heart rate and electrodermal activity baseline values between cultural participant groups

Additional analysis revealed that no differences in absolute HR and EDA baseline values (during the time of the fixation cross) existed between cultural groups in response to both cultural and universal food pictures with α = 0.025. Descriptive statistics and results from the independent samples t-tests for HR and Mann Whitney U tests for EDA can be found in Table 26, 27, 28, and 29 in Appendix A.

4. Discussion

The present study investigated the potential of implicit physiological measures to provide objective measures of affective food experience in contrast to explicit self-report measures. Dutch and Thai participants viewed 120 food pictures from the CROCUFID database portraying typically Dutch and Thai foods, and universal molded and regular foods (considered familiar to everyone). Genuine response differences would be expected for cultural foods due to differences in emotional experience, but not (or weaker) for universal foods. Participants' physiological responses (implicit measures) were measured during the experiment and participants rated their emotional response and hedonic liking (explicit measures) towards each picture.

Participants also indicated their familiarity with each food picture to get an impression of whether our manipulation with food familiarity worked well. The results show it did for both the cultural and universal stimulus set. There is a small but significant difference in the familiarity with universal food pictures between Dutch and Thai participants. However, looking at the familiarity rating pattern (Figure 4), we note that this may be explained by response biases resulting in a pseudo-discrepancy in familiarity level between the participant groups. Nevertheless, a true difference in familiarity impacting on the universal stimulus set results cannot be ruled out.

Results from the explicit measures towards Dutch and Thai (cultural) food pictures confirm our first hypothesis. We expected that (H1) explicit measures are culturally determined in two ways: through the genuine differences in emotional experience with the food and through cultural response biases. More specifically, it was expected that participants would rate foods from their own culture (familiar food pictures) as more pleasant than unfamiliar foods (Torrico et al., 2018a). The results agree with this expectation and show that participants express a greater liking for more familiar food pictures using both the EmojiGrid and hedonic scale. Moreover, Dutch participants express greater liking towards Dutch food pictures compared to Thai participants for Thai pictures, which may indicate the presence of a response bias. Secondly, we hypothesized that (H2) implicit physiological measures merely reflect differences in core affective experience between Dutch and Thai participants without being affected by cultural response biases. Although the response pattern is in the expected direction (Figure 10 and 11), HR and EDA are only partially sensitive in differentiating between familiar and unfamiliar pictures. Therefore, the second hypothesis needs to be rejected. Dutch and Thai participants only respond differently towards Thai pictures for HR and Dutch pictures for EDA. Consistent with literature on the orienting response (Bradley, 2009; Verastegui-Tena et al., 2018), Dutch participants show a larger HR decrease in response to Thai (novel) food pictures. However, in contrast with the literature on this response, Dutch participants show a larger increase in EDA towards familiar Dutch food pictures instead of the envisioned novel Thai pictures. An explanation for this inconsistency is that electrodermal reactions are generally higher for pleasant stimuli (Dutch food pictures in case of Dutch participants) than for neutral stimuli (Thai food pictures in case of Dutch participants) (Bradley, & Lang, 2007). Additionally, the results suggest that Thai participants are less aroused by the food pictures than Dutch participants.

Analysis of explicit responses towards molded and regular (universal) food pictures shows the usage of an extreme response style (tendency to answer using the end-points of rating scales) by Dutch participants and utilization of a middle response style (tendency to answer using the neutral response categories) by Thai participants, and thereby confirms that (H3) explicit measures are affected by cultural response biases. Dutch participants rate the molded food pictures as lower in valence and the regular pictures as higher in valence than Thai participants using both the EmojiGrid and hedonic scale. Effect sizes suggest that the EmojiGrid is less sensitive for cultural response biases, which is in accordance with its' notion of being intuitive and graphical (Toet et al., 2018). Additionally, the universal U-shape relation between valence and arousal observed for affective stimuli was recreated in our experiment (Kuppens et al., 2017; Toet et al., 2018). Lastly, we hypothesized that (H4) implicit physiological responses towards universal food pictures are culturally invariant, as the food is assumed to be similarly familiar to both participant groups and biological responding is similar, while there will be no influence of cultural response biases. This hypothesis needs to be rejected because Dutch and Thai participants have different HR responses upon viewing the molded food pictures. Although both groups show no difference in EDA responses for molded and regular pictures, EDA is not sensitive in differentiating between these picture sub-types whereby results regarding this metric cannot be reliably interpreted. Contrasting the EmojiGrid arousal scores and HR reveals that Thai participants relatively report being as aroused by the molded food pictures as Dutch participants, while their physiological data suggest that they are in fact less aroused. Comparing the HR responses from the cultural stimulus set (Figure 10) to the universal set (Figure 16), it can be noted that there is a similar tendency for the participant groups in responding towards 'unfamiliar' pictures. By 'unfamiliar' we mean the Thai and molded food pictures for Dutch participants, and the Dutch and molded food pictures for Thai participants. After all, we encounter molded foods less often than regular foods wherefore these pictures can be interpreted as somewhat unfamiliar as well. The lower arousal ratings and physiological responses of Thai participants can be interpreted within the context that Westerners and Americans value, promote, and experience high arousal emotions more than people from Asian countries (Lim, 2016). However, a potential biological difference in physiological responding between cultural groups can also not be ruled out.

A limitation of this study is that the instructions, and hedonic scale and familiarity survey anchors were in English instead of in the native's language of the participant groups. There are indications that respondents are more likely to choose neutral (middle) responses in a non-native language survey compared to a survey in the native language (Harzing, 2006). Although English is not the native language of both participant groups, the experiment leaders observed that Dutch participants were more proficient in English than Thai participants. This factor may therefore contribute to finding the typical response style characteristics. Analysis at the individual level revealed some considerable variation among participants in responding to the EmojiGrid (see Figure 1 in Appendix B for some examples). This suggests participants should get some practice trials to get used with responding to the EmojiGrid or should be given some more elaborate instructions. Another limitation is that testing took place at multiple testing locations with different experiment leaders. Although precaution was taken to reduce the influence of external factors as much as possible, variables as the temperature difference between The Netherlands and Thailand may have confounded the physiological measurements (Boucsein, 2012; Madaniyazi et al., 2016), even though it should be noted that we tested for differences in HR and EDA responses rather than absolute levels. Moreover, no differences between cultural groups were found in the absolute HR and EDA baseline values for both stimulus sets. Nevertheless, results regarding the physiological variables in this paper should be considered as preliminary since they only reflect a first rough analysis, in which we averaged across the ten seconds of picture presentation rather than exploring the most sensitive time window within these ten seconds. More extensive analysis is needed to draw more firm conclusions regarding these variables.

Overall, our results are consistent with the literature on response style characteristics of cultural groups (Chen, Lee, & Stevenson, 1995; Johnson, Kulesa, Cho, & Shavitt, 2005; Kaneko et al., 2018c). The results from this study give the impression that physiological measures have potential to discriminate between familiar and unfamiliar food pictures. Heart rate seems most sensitive in comparing core affective food experiences between cultural participant groups and is able to reveal contradictory responses in explicit versus implicit responses towards food pictures. This implies that food affective research may benefit from the addition of physiological measures since these can provide new insights. However, more research is needed to clear up potential biological differences in physiological responding between cultural groups, to investigate the effect of different stimuli types (food pictures versus real food) on the sensitivity of the measures, and to investigate the practical implications of using physiological measures in food affective research. In conclusion, physiological measures suggest to enable a more objective comparison of core affective food experiences across cultures, although this cannot yet be said with certainty.

References

Anderson, A. K., Wais, P. E., & Gabrieli, J. D. (2006). Emotion enhances remembrance of neutral events past. *Proceedings of the National Academy of Sciences*, *103*(5), 1599-1604. doi: 10.1073/pnas.0506308103

Appelhans, B. M., & Luecken, L. J. (2006). Heart rate variability as an index of regulated emotional responding. *Review of General Psychology*, *10*(3), 229-240. doi: 10.1037/1089-2680.10.3.229

Ares, G. (2018). Methodological issues in cross-cultural sensory and consumer research. *Food Quality and Preference*, *64*, 253-263. doi: 10.1016/j.foodqual.2016.10.007

Bach, A. J., Stewart, I. B., Minett, G. M., & Costello, J. T. (2015). Does the technique employed for skin temperature assessment alter outcomes? A systematic review. *Physiological Measurement*, *36*(9), 27-51. doi: 10.1088/0967-3334/36/9/R27

Baumgartner, H., & Steenkamp, J. B. E. (2001). Response styles in marketing research: A cross-national investigation. *Journal of Marketing Research*, *38*(2), 143-156. doi: 10.1509/jmkr.38.2.143.18840

Benedek, M. & Kaernbach, C. (2010). A continuous measure of phasic electrodermal activity. *Journal of Neuroscience Methods, 190,* 80-91. doi:10.1016/j.jneumeth.2010.04.028

Beyts, C., Chaya, C., Dehrmann, F., James, S., Smart, K., & Hort, J. (2017). A comparison of self-reported emotional and implicit responses to aromas in beer. *Food Quality and Preference*, *59*, 68-80. doi: 10.1016/j.foodqual.2017.02.006

Boucsein, W. (2012). *Electrodermal activity*. Berlin, Germany: Springer Science & Business Media.

Bradley, M. M., & Lang, P. J. (2007). Emotion and Motivation. In J. T. Cacioppo, L. G. Tassinary, & G. Berntson (Eds.), *Handbook of Psychophysiology* (pp. 581-607). Cambridge, United Kingdom: Cambridge University Press.

Bradley, M. M. (2009). Natural selective attention: Orienting and emotion. *Psychophysiology*, *46*(1), 1-11. doi: 10.1111/j.1469-8986.2008.00702.x

Braithwaite, J. J., Watson, D. G., Jones, R., & Rowe, M. (2013). A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments. *Psychophysiology*, *49*(1), 1017-1034. *Food Quality and Preference*, *59*, 68-80. doi: 10.1016/j.foodqual.2017.02.006

Brouwer, A. M., Van den Broek, T. J., Hogervorst, M. A., Kaneko, D., Toet, A., Kallen, V., & Van Erp, J. B. (2018). Estimating affective taste experience using combined implicit behavioral and neurophysiological measures. *Manuscript submitted for publication.*

Burger, K. S., Cornier, M. A., Ingebrigtsen, J., & Johnson, S. L. (2011). Assessing food appeal and desire to eat: the effects of portion size & energy density. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 101-110. doi: 10.1186/1479-5868-8-101

Campbell, B. A., Wood, G., & McBride, T. (1997). Origins of orienting and defensive responses: An evolutionary perspective. In P. J. Lang, R. F. Simons, M. Balaban, & R. Simons (Eds.), *Attention and orienting: Sensory and Motivational Processes* (pp. 41-67). New York, NY: Routledge.

Charbonnier, L., van Meer, F., van der Laan, L. N., Viergever, M. A., & Smeets, P. A. (2016). Standardized food images: a photographing protocol and image database. *Appetite*, *96*, 166-173. doi: 10.1016/j.appet.2015.08.041

Chen, C., Lee, S. Y., & Stevenson, H. W. (1995). Response style and cross-cultural comparisons of rating scales among East Asian and North American students. *Psychological Science*, *6*(3), 170-175. doi: 10.1111/j.14679280.1995.tb00327.x

Dalenberg, J. R., Gutjar, S., Ter Horst, G. J., de Graaf, K., Renken, R. J., & Jager, G. (2014). Evoked emotions predict food choice. *PloS One*, *9*(12), e115388. doi: 10.1371/journal.pone.0115388

Danner, L., Haindl, S., Joechl, M., & Duerrschmid, K. (2014). Facial expressions and autonomous nervous system responses elicited by tasting different juices. *Food Research International*, *64*, 81-90. doi: 10.1016/j.foodres.2014.06.003

de Wijk, R. A., Kooijman, V., Verhoeven, R. H., Holthuysen, N. T., & De Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. *Food Quality and Preference*, *26*(2), 196-203. doi:10.1016/j.foodqual.2012.04.015

Dorado, R., Chaya, C., Tarrega, A., & Hort, J. (2016). The impact of using a written scenario when measuring emotional response to beer. *Food Quality and Preference*, *50*, 38-47. doi: 10.1016/j.foodqual.2016.01.004

Drobes, D. J., Miller, E. J., Hillman, C. H., Bradley, M. M., Cuthbert, B. N., & Lang, P. J. (2001). Food deprivation and emotional reactions to food cues: Implications for eating disorders. *Biological Psychology*, *57*(1-3), 153-177. doi: 10.1016/S0301-0511(01)00093-X

Ellsworth, P. C., & Scherer, K. R. (2003). Appraisal processes in emotion. In H. H. Goldsmith, K. R. Scherer, & R. J. Davidson (Eds.), *Handbook of affective sciences* (pp. 525-595). Oxford, United Kingdom: Oxford University Press.

Gutjar, S., de Graaf, C., Kooijman, V., de Wijk, R. A., Nys, A., Ter Horst, G. J., & Jager, G. (2015). The role of emotions in food choice and liking. *Food Research International*, *76*, 216-223. doi:

10.1016/j.foodres.2014.12.022

Hassan, M. A., Malik, A. S., Fofi, D., Saad, N., Karasfi, B., Ali, Y. S., & Mériaudeau, F. (2017). Heart rate estimation using facial video: A review. *Biomedical Signal Processing and Control*, *38*, 346-360. doi: /10.1016/j.bspc.2017.07.004

Harzing, A. W. (2006). Response styles in cross-national survey research: A 26-country study. *International Journal of Cross Cultural Management*, *6*(2), 243-266. doi: 10.1177/ 1470595806066332

He, W., de Wijk, R. A., De Graaf, C., & Boesveldt, S. (2016). Implicit and explicit measurements of affective responses to food odors. *Chemical Senses*, *41*(8), 661-668. doi: 10.1093/chemse/ bjw068

Hebb, D. O. (1946). Emotion in man and animal: an analysis of the intuitive processes of recognition. *Psychological Review*, *53*(2), 88-106. doi: 10.1037/h0063033

Hebb, D. O. (1949). *The organization of behavior. A neuropsychological theory.* NY, New York: John Wiley & Sons.

Hebb, D. O. (1958). *A textbook of psychology.* Philadelphia, PA: Saunders.

Inquisit 4. (2015). Retrieved from https://www.millisecond.com

Johnson, T., Kulesa, P., Cho, Y. I., & Shavitt, S. (2005). The relation between culture and response styles: Evidence from 19 countries. *Journal of Cross-Cultural Psychology*, *36*(2), 264-277. doi: 10.1177/0022022104272905

Kaneko, D., Hogervorst, M., Toet, A., Van Erp, J., Kallen, V., & Brouwer, A. M. (2018a). Explicit ratings and physiological responses to the taste of drinks varying in valence and arousal. *Manuscript submitted for publication.*

Kaneko, D., Toet, A., Brouwer, A. M., Kallen, V., & Van Erp, J. B. (2018b). Methods for evaluating emotions evoked by food experiences: a literature review. *Frontiers in Psychology*, *9*, 911-931. doi: 10.3389/fpsyg.2018.00911

Kaneko, D., Toet, A., Ushiama, S., Brouwer, A. M., Kallen, V., & Van Erp, J. B. (2018c). EmojiGrid: A 2D pictorial scale for cross-cultural emotion assessment of negatively and positively valenced food. *Food Research International, 115,* 541-551. doi: 10.1016/j.foodres.2018.09.049

Köster, E. P., & Mojet, J. (2006). Theories of food choice development. In L. J. Frewer, & J. C. M. Trijp (Eds.), *Understanding consumers of food products* (pp. 93–124). Cambridge, United Kingdom: Woodhead Publishing. doi: 10.1201/ 9781439824504.ch4

Köster, E. P., & Mojet, J. (2015). From mood to food and from food to mood: A psychological perspective on the measurement of food-related emotions in consumer research. *Food Research International*, *76*, 180-191. doi: 10.1016/j.foodres.2015.04.006

Kranjec, J., Beguš, S., Geršak, G., & Drnovšek, J. (2014). Non-contact heart rate and heart rate variability measurements: A review. *Biomedical Signal Processing and Control*, *13*, 102-112. doi: 10.1016/j.bspc.2014.03.004

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological Psychology*, *84*(3), 394-421. doi: 10.1016/j. biopsycho.2010.03.010

Kuoppa, P., Pulkkinen, K., Tarvainen, M. P., Lankinen, M., Lapveteläinen, A., Sinikallio, S., Karhunen, S., Karjalainen, L., Kolehmainen, P. A., Sallinen, M., & Närväinen, J. (2016). Psychophysiological responses to positive and negative food and nonfood visual stimuli. *Journal of Neuroscience, Psychology, and Economics*, *9*(2), 78-88. doi: 10.1037/npe0000053

Kuppens, P., Tuerlinckx, F., Yik, M., Koval, P., Coosemans, J., Zeng, K. J., & Russell, J. A. (2017). The relation between valence and arousal in subjective experience varies with personality and culture. *Journal of Personality*, *85*(4), 530-542. doi: 10.1111/jopy.12258

Lagast, S., Gellynck, X., Schouteten, J. J., De Herdt, V., & De Steur, H. (2017). Consumers' emotions elicited by food: A systematic review of explicit and implicit methods. *Trends in Food Science & Technology*, *69*, 172-189. doi:10.1016/ j.tifs.2017.09.006

Lawless, H. T., & Heymann, H. (2010). Scaling. In H. T. Lawless, & H. Heymann (Eds.), *Sensory evaluation of food: Principles and practices* (pp. 149–174). New York, NY: Springer.

Lim, J. (2011). Hedonic scaling: A review of methods and theory. *Food Quality and Preference*, *22*(8), 733-747. doi: /10.1016/j.foodqual.2011. 05.008

Lim, N. (2016). Cultural differences in emotion: differences in emotional arousal level between the East and the West. *Integrative Medicine Research, 5*(2), 105 – 109. doi: 10.1016/j.imr.2016.03.004

Madaniyazi, L., Zhou, Y., Li, S., Williams, G., Jaakkola, J. J., Liang, X., Liu, Y., Wu, S., & Guo, Y. (2016). Outdoor temperature, heart rate and blood pressure in Chinese adults: effect modification by individual characteristics. *Scientific Reports*, *6*, 21003. doi: 10.1038/ srep21003

McGaugh, J. L. (2006). Make mild moments memorable: add a little arousal. *Trends in Cognitive Sciences*, *10*(8), 345-347. doi:10.1016/ j.tics.2006.06.001

Meiselman, H. L. (2013). The future in sensory/consumer research: Evolving to a better science. *Food Quality and Preference*, *27*(2), 208-214. doi: 10.1016/j.foodqual.2012.03.002

Mendes, W. B. (2009). Assessing autonomic nervous system activity. In J. S. Beer, & E. Harmon-Jones (Eds.), *Methods in social neuroscience* (pp. 118-147). New York, NY: Guilford Press.

Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preferences. *Food Technology, 11*, 9-14.

Prescott, J. (2017). Some considerations in the measurement of emotions in sensory and consumer research. *Food Quality and Preference*, *62*, 360-368. doi: 10.1016/j.foodqual.2017.04.005

Rozin, P. (1988). Cultural approaches to human food preferences. In J. E. Morley, M. B. Sterman, & J. H. Walsh (Eds.), *Nutritional Modulation of Neural Function* (pp. 137–153). San Diego, CA: Academic Press.

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39*(6), 1161-1178. doi: 10.1037/ h0077714

Samant, S. S., Chapko, M. J., & Seo, H. S. (2017). Predicting consumer liking and preference based on emotional responses and sensory perception: A study with basic taste solutions. *Food Research International*, *100*, 325-334. doi: 10.1016/j.foodres.2017.07.021

Schutz, P. A., Quijada, P. D., de Vries, S., & Lynde, M. (2007). Emotion in Education. In G. D. Phye (Ed.), *International Encyclopedia of Education* (pp. 591-596). San Diego, CA: Academic Press.

Simmons, W. K., Martin, A., & Barsalou, L. W. (2005). Pictures of appetizing foods activate gustatory cortices for taste and reward. *Cerebral Cortex*, *15*(10), 1602-1608. doi: 10.1093/cercor/ bhi038

Soto, J. A., Levenson, R. W., & Ebling, R. (2005). Cultures of moderation and expression: emotional experience, behavior, and physiology in Chinese Americans and Mexican Americans. *Emotion*, *5*(2), 154-165. doi: 10.1037/1528-3542.5.2.154

Soto, J. A., Lee, E. A., & Roberts, N. A. (2016). Convergence in feeling, divergence in physiology: How culture influences the consequences of disgust suppression and amplification among European Americans and Asian Americans. *Psychophysiology, 53*(1), 41-51. doi: 10.1111/ psyp.12579

Tang, D. W., Fellows, L. K., Small, D. M., & Dagher, A. (2012). Food and drug cues activate similar brain regions: a meta-analysis of functional MRI studies. *Physiology & Behavior*, *106*(3), 317-324. doi: 10.1016/j.physbeh.2012.03.009

Toet, A., Kaneko, D., Ushiama, S., Hoving, S., De Kruijf, I., Brouwer, A. M., Kallen, V., & Van Erp, J. B. (2018). EmojiGrid: a 2D pictorial scale for the assessment of food elicited emotions. *Frontiers in Psychology*, *9*, 23-96. doi: 10.3389/fpsyg.2018. 02396

Toet, A., Kaneko, D., De Kruijf, I., Ushiama, S., Van Schaik, M. G., Brouwer, A. M., Kallen, V., & Van Erp, J. B. (2019). CROCUFID: A cross-cultural food image database for research on food elicited affective responses. *Frontiers in Psychology, 10*(58). doi: 10.3389/fpsyg.2019. 00058

Torrico, D. D., Fuentes, S., Viejo, C. G., Ashman, H., & Dunshea, F. R. (2018a). Cross-cultural effects of food product familiarity on sensory acceptability and non-invasive physiological responses of consumers. *Food Research International*, *115*, 439–450. doi: 10.1016/j.foodres.2018.10.054

Torrico, D. D., Fuentes, S., Viejo, C. G., Ashman, H., Gunaratne, N. M., Gunaratne, T. M., & Dunshea, F. R. (2018b). Images and chocolate stimuli affect physiological and affective responses of consumers: A cross-cultural study. *Food Quality and Preference*, *65*, 60-71. doi: 10.1016/j.foodqual.2017.11.010

Tsai, J. L., Levenson, R. W., & Carstensen, L. L. (2000). Autonomic, subjective, and expressive responses to emotional films in older and younger Chinese Americans and European Americans. *Psychology and Aging*, *15*(4), 684-693. doi: 10.1037/0882-7974.15.4.684

Tsai, J. L., Chentsova-Dutton, Y., Freire-Bebeau, L., & Przymus, D. E. (2002). Emotional expression and physiology in European Americans and Hmong Americans. *Emotion*, *2*(4), 380-397. doi: 10.1037/1528-3542.2.4.380

Tuorila, H., Lähteenmäki, L., Pohjalainen, L., & Lotti, L. (2001). Food neophobia among the Finns and related responses to familiar and unfamiliar foods. *Food Quality and Preference*, *12*(1), 29-37. doi: 10.1016/S0950-3293(00)00025-2

van der Laan, L. N., De Ridder, D. T., Viergever, M. A., & Smeets, P. A. (2011). The first taste is always with the eyes: a meta-analysis on the neural correlates of processing visual food cues. *Neuroimage*, *55*(1), 296-303. doi: 10.1016 /j.neuroimage.2010.11.055

van Zyl, H., & Meiselman, H. L. (2015). The roles of culture and language in designing emotion lists: Comparing the same language in different English and Spanish speaking countries. *Food Quality and Preference*, *41*, 201-213. doi: 10.1016/j.foodqual. 2014.12.003

van Zyl, H., & Meiselman, H. L. (2016). An update on the roles of culture and language in designing emotion lists: English, Spanish and Portuguese. *Food Quality and Preference*, *51*, 72-76. doi: 10.1016/j.foodqual.2016.02.019

Verastegui-Tena, L., van Trijp, H., & Piqueras-Fiszman, B. (2018). Heart rate and skin conductance responses to taste, taste novelty, and the (dis)confirmation of expectations. *Food Quality and Preference, 65*, 1-9. doi: 10.1016/j. foodqual.2017.12.012

World Medical Association (2013). World Medical Association declaration of Helsinki: Ethical principles for medical research involving human subjects. *Journal of the American Medical Association, 310*(20), 2191–2194. doi: 10.1001/ jama. 2013.281053

Zukerman, M. (1969). Theoretical Formulations: I. In J. P. Zubek (Ed.), *Sensory Deprivation: Fifteen years of research* (pp. 407–432). New York, NY: Meredith Corporation.

Appendix A. Supplementary results

Table 1. *Descriptive statistics for the familiarity scores from Dutch and Thai participants towards Dutch, Thai, and universal regular food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Dutch food pictures	Dutch	45	3.91	0.38
	Thai	42	1.88	0.53
Thai food pictures	Dutch	45	1.59	0.30
	Thai	42	3.50	0.41
Regular food pictures	Dutch	45	4.11	0.39
	Thai	42	3.45	0.42

Table 2. *Pairwise comparisons using Bonferroni correction between familiarity scores from Dutch and Thai participants towards Dutch, Thai, and universal regular food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	2.03	0.10	< .001	1.83, 2.22
Thai food pictures	Dutch – Thai participants	-1.91	0.08	< .001	-2.06, -1.76
Regular food pictures	Dutch – Thai participants	0.67	0.09	< .001	0.49, 0.84

Table 3. *Descriptive statistics for the EmojiGrid valence scores from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Dutch food pictures	Dutch	45	74.13	7.60
	Thai	42	58.11	9.70
Thai food pictures	Dutch	45	56.87	12.05
	Thai	42	65.15	8.80

Table 4. *Pairwise comparisons using Bonferroni correction between EmojiGrid valence scores from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	16.02	1.86	< .001	12.31, 19.72
Thai food pictures	Dutch – Thai participants	-8.27	2.28	< .001	-12.80, -3.75

Table 5. *Descriptive statistics for the EmojiGrid arousal scores from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Dutch food pictures	Dutch	45	56.78	13.19
	Thai	42	46.29	14.24
Thai food pictures	Dutch	45	52.04	12.08
	Thai	42	49.92	12.34

Table 6. *Pairwise comparisons using Bonferroni correction between EmojiGrid arousal scores from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	10.49	2.94	0.001	4.64, 16.33
Thai food pictures	Dutch – Thai participants	2.12	2.62	0.421	-3.09, 7.33

Table 7. *Descriptive statistics for the hedonic liking scores from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Dutch food pictures	Dutch	45	6.73	0.58
	Thai	42	5.41	0.61
Thai food pictures	Dutch	45	5.43	0.90
	Thai	42	5.93	0.54

Table 8. *Pairwise comparisons using Bonferroni correction between hedonic liking scores from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	1.32	0.13	< .001	1.07, 1.57
Thai food pictures	Dutch – Thai participants	-0.50	0.16	0.002	-0.82, -0.18

Table 9. *Descriptive statistics for the heart rate responses from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Dutch food pictures	Dutch	45	- 0.99	1.55
	Thai	39	- 0.74	1.42
Thai food pictures	Dutch	45	- 1.76	1.50
	Thai	39	- 0.60	0.98

Table 10. *Pairwise comparisons using Bonferroni correction between heart rate responses from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	-0.26	0.33	0.437	-0.90, 0.39
Thai food pictures	Dutch – Thai participants	-1.16	0.28	< .001	-1.72, -0.60

Table 11. *Descriptive statistics for the electrodermal activity responses from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Dutch food pictures	Dutch	45	41.37	92.02
	Thai	39	- 5.68	69.10
Thai food pictures	Dutch	45	1.14	50.78
	Thai	39	6.55	76.41

Table 12. *Pairwise comparisons using Bonferroni correction between electrodermal activity responses from Dutch and Thai participants towards cultural food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	47.05	17.98	0.011	11.27, 82.82
Thai food pictures	Dutch – Thai participants	-5.41	13.99	0.700	-33.25, 22.42

Table 13. *Results from the independent samples t-tests on heart rate responses from Dutch and Thai participants towards cultural food pictures.*

Cultural group	Comparison	Mean difference	*SE*	*t*	*p*	95% CI (lower, upper)
Dutch	Dutch – Thai pictures	0.76	0.32	2.38	0.020	0.13, 1.40
Thai	Dutch – Thai pictures	-0.14	0.28	-0.51	0.613	-0.69, 0.41

Table 14. *Results from the Mann Whitney U tests on electrodermal activity responses from Dutch and Thai participants towards cultural food pictures.*

Cultural group	Comparison	*U*	*Z*	*p*
Dutch	Dutch – Thai pictures	781.00	-1.87	0.062
Thai	Dutch – Thai pictures	699.00	-0.62	0.539

Table 15. *Descriptive statistics for the EmojiGrid valence scores from Dutch and Thai participants towards universal food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Molded food pictures	Dutch	45	7.67	5.33
	Thai	42	13.13	8.52
Regular food pictures	Dutch	45	76.27	7.08
	Thai	42	64.78	7.70

Table 16. *Pairwise comparisons using Bonferroni correction between EmojiGrid valence scores from Dutch and Thai participants towards universal food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	-5.46	1.51	0.001	-8.46, -2.45
Thai food pictures	Dutch – Thai participants	11.49	1.59	< .001	8.34, 14.64

Table 17. *Descriptive statistics for the EmojiGrid arousal scores from Dutch and Thai participants towards universal food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Molded food pictures	Dutch	45	75.11	19.11
	Thai	42	68.07	18.65
Regular food pictures	Dutch	45	57.61	10.65
	Thai	42	50.23	11.14

Table 18. *Pairwise comparisons using Bonferroni correction between EmojiGrid arousal scores from Dutch and Thai participants towards universal food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	7.05	4.05	0.086	-1.01, 15.10
Thai food pictures	Dutch – Thai participants	7.38	2.34	0.002	2.73, 12.02

Table 19. *Descriptive statistics for the hedonic liking scores from Dutch and Thai participants towards universal food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Molded food pictures	Dutch	45	1.50	0.43
	Thai	42	1.88	0.79
Regular food pictures	Dutch	45	6.94	0.46
	Thai	42	5.97	0.52

Table 20. *Pairwise comparisons using Bonferroni correction between hedonic liking scores from Dutch and Thai participants towards universal food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	-0.38	0.14	0.006	-0.65, -0.12
Thai food pictures	Dutch – Thai participants	0.97	0.11	< .001	0.76, 1.18

Table 21. *Descriptive statistics for the heart rate responses from Dutch and Thai participants towards universal food pictures.*

Picture sub-type	Cultural group	N	*M*	*SD*
Molded food pictures	Dutch	45	- 2.76	1.90
	Thai	39	- 0.70	1.81
Regular food pictures	Dutch	45	- 1.03	1.42
	Thai	39	- 0.65	0.85

Table 22. *Pairwise comparisons using Bonferroni correction between heart rate responses from Dutch and Thai participants towards universal food pictures.*

Picture sub-type	Comparison	Mean difference	*SE*	*p*	95% CI (lower, upper)
Dutch food pictures	Dutch – Thai participants	-2.05	0.41	< .001	-2.86, -1.24
Thai food pictures	Dutch – Thai participants	-0.38	0.26	0.153	-0.89, 0.14

Table 23. *Results from the independent samples t-tests on heart rate responses from Dutch and Thai participants towards cultural food pictures.*

Cultural group	Comparison	Mean difference	*SE*	*t*	*p*	95% CI (lower, upper)
Dutch	Dutch – Thai pictures	-1.72	0.35	-4.89	< .001	-2.43, -1.03
Thai	Dutch – Thai pictures	-0.05	0.32	-0.16	0.871	-0.69, 0.59

Table 24. *Descriptive statistics for the electrodermal activity responses from Dutch and Thai participants towards universal food pictures.*

Picture sub-type	**Cultural group**	**N**	***M***	***SD***
Molded food pictures	Dutch	45	16.69	87.10
	Thai	39	- 4.33	108.84
Regular food pictures	Dutch	45	13.99	60.14
	Thai	39	7.47	69.32

Table 25. *Results from the mixed model ANOVA with within-subject factor picture sub-type (molded food pictures, regular food pictures) and between-subject factor cultural group (Dutch, Thai) on electrodermal activity responses.*

Effect	***F***	***p***
Picture sub-type	0.17	0.682
Cultural group	0.92	0.340
Picture sub-type × cultural group	0.43	0.515

Table 26. *Descriptive statistics for the heart rate baseline values from Dutch and Thai participants towards cultural and universal food pictures.*

Picture sub-type	**Cultural group**	**N**	***M***	***SD***
Cultural	Dutch	45	78.11	11.64
	Thai	39	78.49	9.15
Universal	Dutch	45	77.60	11.72
	Thai	39	78.05	10.20

Table 27. *Results from the independent samples t-tests on heart rate baseline values from Dutch and Thai participants towards cultural and universal food pictures.*

Picture sub-type	**Comparison**	**Mean difference**	***SE***	***t***	***p***	**95% CI (lower, upper)**
Cultural	Dutch – Thai participants	-0.36	2.31	-0.17	0.868	-4.98, 4.21
Universal	Dutch – Thai participants	-0.45	2.42	-0.19	0.852	-5.26, 4.35

Table 28. *Descriptive statistics for the electrodermal activity baseline values from Dutch and Thai participants towards cultural and universal food pictures.*

Picture sub-type	**Cultural group**	**N**	***M***	***SD***
Cultural	Dutch	45	156.52	110.34
	Thai	39	193.55	157.64
Universal	Dutch	45	144.15	105.75
	Thai	39	209.83	170.68

Table 29. *Results from the Mann Whitney U tests on electrodermal activity baseline values from Dutch and Thai participants towards cultural and universal food pictures.*

Picture sub-type	**Comparison**	***U***	***Z***	***p***
Cultural	Dutch – Thai participants	792.00	-0.77	0.443
Universal	Dutch – Thai participants	698.00	-1.61	0.107

Appendix B. Examples of individual EmojiGrid responses

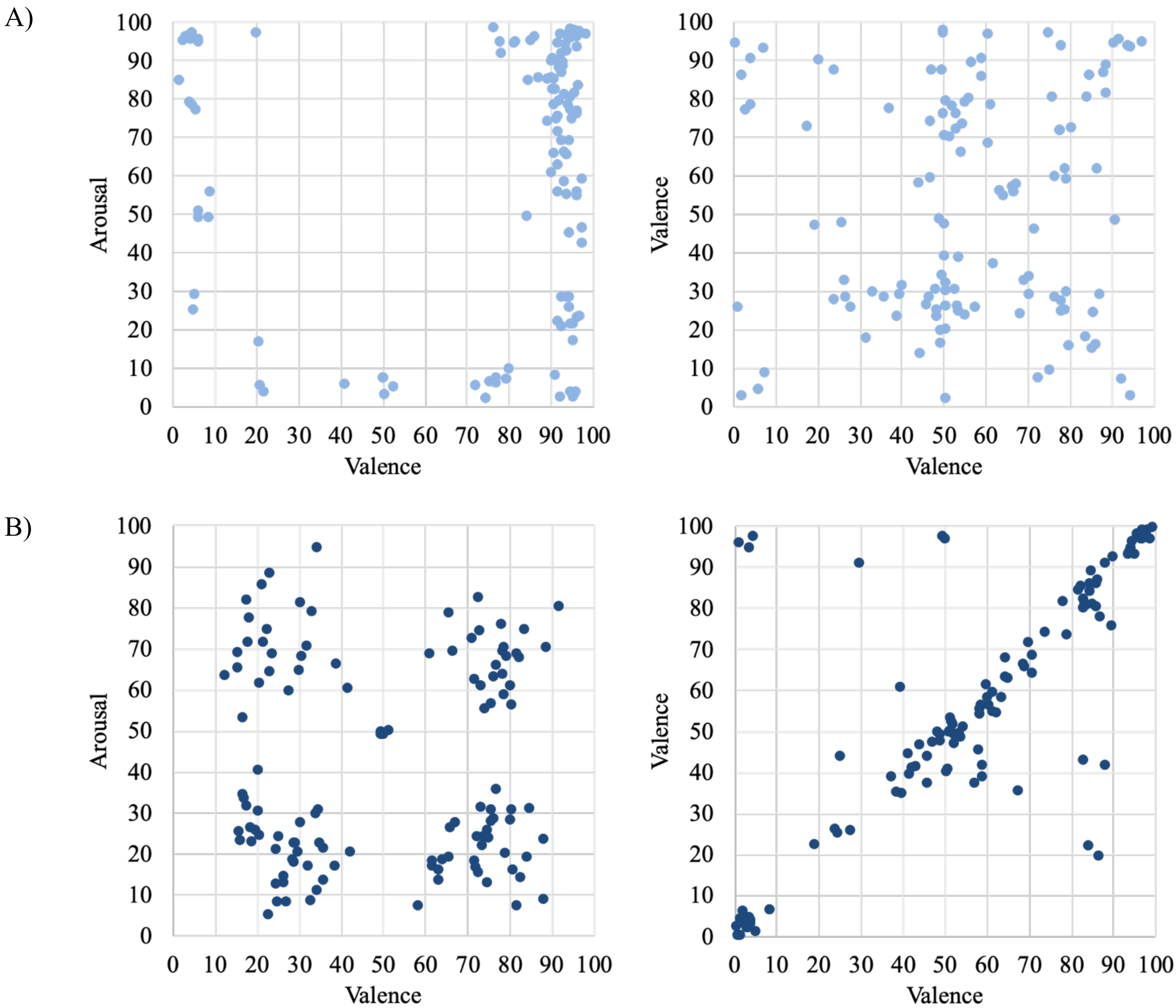

Figure 1. Examples of individual differences in EmojiGrid response patterns for (A) two Dutch and (B) two Thai participants.