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Short Communication

Unspeeded response time as an implicit measure of food appraisal

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ABSTRACT

Affective responses are often adopted as proxy measures of potential food choices. To reliably assess affective responses there is a need for implicit measures that are less prone to cognitive biases, context, lack of introspective capacity, social desirability, and intercultural differences than the explicit self-report measures that are commonly used. In this study, we investigated the relation between unspeeded response time (URT) and the affective appraisal (in terms of valence and arousal) for food images. We find that URT is negatively correlated with both absolute valence and arousal: URT is larger for food images that are rated near-neutral (ambiguous) on valence and low on arousal than for images eliciting more extreme positive and negative affective ratings. Participants need more time for the affective evaluation of food images with lower emotional clarity than those with clear-cut emotional quality. Hence, the URT may serve as a continuous and easily observable implicit evaluation measure that complements self-report measures.

1. Introduction

Since food-evoked emotions significantly predict consumers' food choices, a plethora of measures have been developed to assess food-evoked emotions. A popular approach to assessing human emotional responses to food is explicitly registering a participant's self-reported feelings while viewing food imagery (Kaneko, Toet, Brouwer, Kallen, & van Erp, 2018). While affective responses are typically adopted as proxy measures of potential food choices, there appears to be only a weak correspondence between explicit ratings and ultimate consumer behavior. Implicit measures may contribute to a better understanding of consumers' food-evoked emotions since they are less prone to cognitive biases, social pressure, context, lack of introspective capability, and intercultural differences. This study investigates whether the response time in an unspeeded explicit appraisal task may serve as an implicit evaluation measure. Thereto, we measured the relation between the explicit affective appraisal of food images and the time participants take for their assessment.

According to two-dimensional models of affect (e.g. Kuppens, Tuerlinckx, Russell, & Barrett, 2013; Mattek, Wolford, & Whalen, 2017), emotions can be characterized by their valence (i.e., pleasantness: the degree of positive or negative affective response to a stimulus) and arousal (the degree of activation or deactivation associated with the affective response to a stimulus). Valence describes a stimulus's intrinsic attractiveness (positive valence or pleasantness) or averseness (negative valence or unpleasantness). Arousal represents the activation of the sympathetic nervous system in response to a perceived stimulus. While the dimensions of valence and arousal are dissociable to some extent, they are not entirely independent (Kuppens et al., 2013; Mattek et al., 2017). For instance, Mattek et al. (2017) argued that valence can be depicted as a bipolar dimension that moves from negative to positive through maximal ambiguity (rather than neutrality). Valence and arousal are correlated when valence is not ambiguous (i.e., for more extreme valences, both positive and negative) but not when valence is ambiguous (Mattek et al., 2017). Emotions with either extremely negative or positive valence score higher on arousal, and emotions with neutral (or ambiguous) valence score lower on arousal, resulting in a U-shaped relation when arousal is plotted as a function of valence (Kuppens et al., 2013; Mattek et al., 2017). Although arousal is often adopted as the intensity of an emotion (i.e., the degree of pleasure or displeasure) in the literature, this hypothesis has been questioned (Kuppens et al., 2013). In dimensional models of affect, emotional intensity is typically defined as the distance of an affective state to the neutral midpoint of the valence-arousal scale (typically computed as: $Intensity = \sqrt{valence^2 + arousal^2}$, see e.g., Calvo & Avero, 2009).

According to the diffusion model (Ratcliff, 1978), response time

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Fig. 1. Examples of stimuli used with positive (upper row), neutral (middle row) and negative (lower row) mean valence ratings.

consists of three components reflecting the encoding, evaluation and decision, and response stages. The variability in response time across stimuli is mainly a function of the evaluation and decision component. Since this component is likely to increase with stimulus ambiguity (or uncertainty), we expect (H1) that the response time will vary as a Piéron's function of stimulus uncertainty (Bonnet, Ars, & Ferrer, 2008) being shorter for food images with a less ambiguous (e.g., familiar food images) or more extreme (positive or negative) valence than for images with an ambiguous (near-neutral) valence. Inverted U-shaped relations have indeed been observed (a) between valence and response time in a speeded reaction time experiment (i.e., with the instruction to respond as quickly as possible) for emotional images (Calvo & Avero, 2009), (b) between the rated degree of agreement to craving-related items and response time in a self-paced experiment (Germeroth, Wray, & Tiffany, 2015), (c) between valence and processing time of emotional words in a speeded reaction time experiment (Kousta, Vinson, & Vigliocco, 2009), and (d) between the rated valence of activities and response time in a self-paced experiment (Tracey & Tao, 2018). In a speeded reaction time experiment, Pavlovian stimuli of both positive and negative valence yielded shorter reaction times than neutral stimuli (Huys et al., 2011). Also, Kaye et al. (2021) reported shorter reaction times for emotionally negative and positive valenced stimuli (words, faces, and emoji) than for near-neutral stimuli. Agovi et al. (2022) found a strong inverse correlation between mean reaction time and mean valence or liking ratings for food names. As for food images, Wolf et al. (2019) measured the relation between preference ratings and both viewing (i.e., fixation) time and exposure time, using a self-paced paradigm. Although they reported an inverted U-shape for both relations, they could merely establish a trend, since their categorical rating scale only consisted of three levels (i.e., negative, neutral, positive). To the best of our knowledge, no study has systematically investigated the relation between valence ratings and unspeeded response time (URT) for food images.

According to motivational theories of emotion (Bradley, Codispoti, Cuthbert, & Lang, 2001) the valence of a stimulus determines whether appetitive or defensive motivation is engaged, while the intensity of the emotion it elicits determines the extent of that motivation. If arousal affects stimulus response time, we expect that (H2) affective evaluation responses for food images eliciting more arousing or intense (positive or negative) affective states will be faster than for neutral images since (a) their (ecological) relevance for the approach-avoidance motivational systems is higher and (b) they modulate physiological reactivity more strongly (Bernat, Patrick, Benning, & Tellegen, 2006). However, the literature reports inconsistent and differential effects of stimulus arousal on the processing speed of pleasant and unpleasant stimuli. Using a speeded response task, Calvo and Avero (2009) found that response times decreased linearly with increasing arousal for images with negative valence, while there was no significant relation for images with positive valence. Using an emotional Stroop task, Agovi et al. (2022) found longer response times for vegetables than for neutral objects, suggesting that vegetables were more emotionally arousing than neutral objects. Also using a speeded response paradigm, Purkis, Lipp, Edwards, and Barnes (2009) found shorter reaction times for highly arousing unpleasant images and for low arousing pleasant images than for neutral images.

Emotional responses and affective appraisals involve different processing levels in the brain (Schreuder, van Erp, Toet, & Kallen, 2016) that are differently affected by arousal. Imposing a temporal deadline (as in speeded response tasks) is known to raise arousal from the baseline level (Gross & Dobbins, 2021), which in turn affects the speed of information processing and motor action (Lu, Jaquess, Hatfield, Zhou, & Li, 2017) and may affect perceived valence (Petrolini & Viola, 2020). By using speeded response tasks, the results of most studies reflect the combined effect of emotional stimuli on action or motor responses and affective appraisal or decision processes.

In this study we attempted to isolate the confounding effects of task-induced arousal from stimulus-induced arousal on affective appraisal by analyzing affective responses obtained in an unspeeded response task. The absence of deadlines is likely to minimize task-induced arousal so

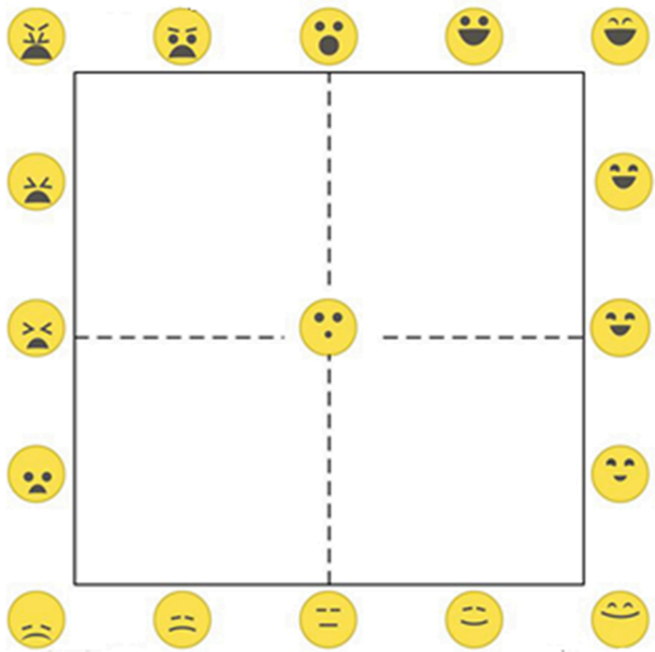

Fig. 2. The EmojiGrid. The iconic facial expressions range from disliking (unpleasant) via neutral to liking (pleasant) along the horizontal (valence) axis, while their intensity increases along the vertical (arousal) axis. This figure has been reproduced with permission from Toet et al. (2018).

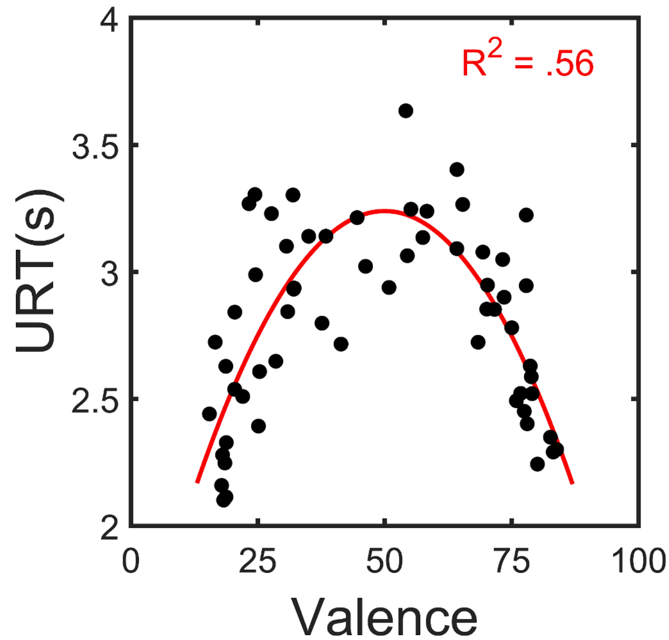

Fig. 3. The relation between mean valence ratings and unspeeded response time (URT) for the 60 food images used in this study (each dot signifies the average score over 139 participants). Values below 50 correspond to negative valence, values larger than 50 represent positive valence. The curve represents a least-squares quadratic fit to the data points.

that perceived arousal will primarily be a result of stimulus perception. Specifically, we investigate the relation between URT and food image valence, arousal and intensity by analyzing a subset of the dataset previously published by Van der Burg et al. (2021). They measured the affective appraisal of food images in terms of valence and arousal with a continuous graphical self-report tool. Their images were selected such that the associated mean valence ratings ranged from negative via ambiguous (near neutral) to positive. In addition to valence and arousal, Van der Burg et al. (2021) also recorded the URT for a subset of their participants, but did not analyze these data.

2. Methods and procedures

In this section we briefly describe the methods and procedures used to collect the dataset that was used in this study. For full details we refer to the publication in which this dataset was first presented (Van der Burg et al., 2021).

2.1. Participants

In this study we used the data of a subset of 139 participants (34 males; 105 females; mean age: 32.6 years, standard deviation: 11.6 years) of the total number of 1322 that participated in the experiment of Van der Burg et al. (2021) and for whom the URT was registered. Exclusion criteria were (color) vision deficiencies. Participation was voluntary and all participants were naïve as to the purpose of the experiment. The experimental protocol was reviewed and approved by the TNO Internal Review Board (approval code: 2019–033, approval date: 10–05-2019). The study was explained to participants in the online questionnaire. All participants acknowledged an informed consent statement in order to participate in the study. Participants were able to withdraw from the survey at any time without providing a reason.

2.2. Stimuli

The stimulus set consisted of the sixty different food images (850 × 640 pixels) that were used in the study by Van der Burg et al. (2021) (some examples are shown in Fig. 1, the complete set of stimuli can be downloaded from https://osf.io/cyqg7/download). The images were selected such that their associated mean valence ratings covered a large part of the entire valence scale. They represent natural food (like e.g., strawberry, salad), rotten or molded food (e.g., rotten banana, molded salad), raw food (e.g., raw potatoes, raw chicken), processed food (e.g., cakes, fried fish), and contaminated food (e.g., hotchpot with fake turd).

2.3. Measures

Valence and arousal ratings were obtained with the EmojiGrid graphical self-report tool (Toet et al., 2018, see also https://en.wikipedia.org/wiki/EmojiGrid). The EmojiGrid is a square grid labeled with facial icons that express various degrees of valence and arousal (Fig. 2). Users rate their affective appraisal of a given stimulus by pointing and clicking at the location on the grid that best represents their impression in terms of valence and arousal. Valence and arousal ratings were scaled to a range between 0 and 100.

The time between the onset of a stimulus presentation and the moment a participant clicked on the EmojiGrid was registered as the URT. At the start of each trial, the cursor appeared at the center of the grid.

2.4. Data analysis

Statistical analyses were performed using the SciPy module in Python and IBM SPSS Statistics 28 (https://www.ibm.com) for Windows. The Curve Fitting Toolbox (version 3.5.7) in Matlab was used to compute least-squares fits to the data points. For all analyses alpha was set to.05.

2.5. Procedure

Participants took part in an anonymous online survey. First, they were informed that during the experiment they would be asked to report

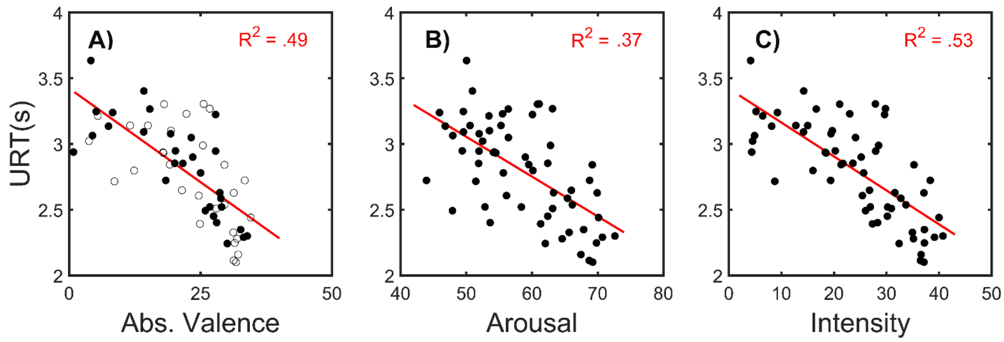

Fig. 4. The relation between unspeeded response time (URT) and (a) absolute mean valence ratings (open and closed symbols represent respectively the negative and positive mean valence ratings from Fig. 3), (b) mean arousal ratings and (c) mean affective intensity. The curves represent least-squares linear fits to the data points.

their first impression of 60 different food images. It was emphasized that there were no correct or incorrect answers and that it was important to respond seriously. Subsequently, participants signed a digital informed consent, affirming that they were at least 18 years old and voluntarily participated in the study. The survey then continued with an assessment of the demographics (age, gender) of the participants. Next, the participants performed two practice trials to get familiar with the EmojiGrid. Subsequently, the 60 stimuli were presented in random order, and the participants reported their affective appraisal for each image along the dimensions of valence and arousal using the EmojiGrid. The experiment was self-paced. The average duration of the experiment was about 15 min.

3. Results

Trials with response times exceeding 10 s were excluded from further analyses (this resulted in the exclusion of 4.2 % of the trials).

Fig. 3 shows the relation between mean valence ratings and unspeeded response time (URT). A least-squares fit to the data points shows that the relation between mean valence and URT is closely described by an inverted U-shaped function ($R^2 = 0.56$). This result agrees with our hypothesis (H1) that the response time will typically be shorter for food images with a less ambiguous or more extreme (positive or negative) valence than for images with an ambiguous (near-neutral) valence.

The curvilinear inverted U-shaped relation in Fig. 3 between self-reported item valence and URT (associating both low and high valence scores with short URTs and moderate valence scores with long URTs) implies that the URT correlates negatively with absolute mean valence (i.e., the difference between the maximal URT and the observed URT). Fig. 4a shows the relation between URT and the absolute mean valence ratings (obtained by mirroring the valence shown in Fig. 3 along the neutral or V = 50 axis), together with a linear least-squares fit to the data points ($R^2 = 0.49$). The linear correlation between URT and absolute valence is $r = -0.70$, $p = 4.3068e\text{-}10$.

Least-squares linear fits to the data points in Fig. 4b and c ($R^2 = 0.37$, and $R^2 = 0.53$, respectively) show that URT also correlates negatively with mean arousal ($r = -0.61$, $p = 2.3235e\text{-}07$, Fig. 4b) and intensity ($r = -0.73$, $p = 5.2552e\text{-}11$, Fig. 4c). These results agree with our hypothesis (H2) that affective evaluation responses for food images eliciting more arousing or intense (positive or negative) affective states will be faster than for neutral images.

4. Discussion

Using a self-paced affective assessment task and food images that cover a wide range of the affective scale, we systematically investigated the relation between URT and perceived valence, arousal and intensity. We find that URT correlates negatively with both absolute valence and arousal. Valence (49 %) explains a larger proportion of variance in the data than arousal (37 %).

The results confirm our hypothesis (H1) that the URT is typically larger for food images that are rated near-neutral (ambiguous) on valence than for images with more extreme affective ratings. Overall, the relation between URT and mean valence shows an inverted U-shape. This result agrees with – and extends – the finding of Wolf et al. (2019) who observed a trend towards an inverted U-shape relation between preference ratings and both viewing (i.e., fixation) time and exposure time when using food images with positive and neutral valence. Thus, participants take more time for the affective evaluation of food images with lower emotional clarity than for the evaluation of food images with a clear-cut emotional quality.

Our results also confirm our hypothesis (H2) that unspeeded affective evaluation responses for food images eliciting more arousing or intense affective states are generally faster than for neutral images, independent of their valence. This result is in contrast with the results of speeded response tasks that show an interaction between valence and arousal, such that faster response times are observed only for stimuli that are congruent in valence and arousal (i.e., high-arousing negative and low-arousing positive stimuli), but not for stimuli where both dimensions are incongruent (i.e., low-arousing negative and high-arousing positive stimuli; Eder & Rothermund, 2010; Purkis et al., 2009; Robinson, Storbeck, Meier, & Kirkeby, 2004). The absence of an interaction effect in our study may reflect the distinct processing levels mediating real-time (speeded) processing and unspeeded evaluation of affective stimuli (Cacioppo, Gardner, & Berntson, 1999).

These findings suggests that URT may serve as an additional and implicit measure to infer the affective appraisal of food that helps to overcome some of the major limitations of explicit evaluation methods. Explicit measures of core affect are probably more reliable as predictors of eventual user behavior when they are supported by (in agreement with) implicit measures. Discrepancies between explicit and implicit responses signal consumer uncertainty that may ultimately lead to a larger behavioral variability. Given that measures of food preferences are nowadays typically administered via computer or internet, the ability to also gather response time is a simple addition to existing research protocols that may serve to improve the reliability and validity of their results.

4.1. Limitations

The current study also has some limitations.

We only measured the overall URT, and not the fixation time (the time the food is actually visually inspected) or the time that is actually needed to make the affective assessment (the evaluation or cognitive evaluation component of the URT). For the future, it would be interesting to measure eye-movements while participants perform the task to examine whether the inspection time or decision time increases when participants rate ambiguous food.

Response time alone yields little information about food preferences.

A practical application requires knowledge of the response time distribution and should combine response time with one or more regular measures.

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CRediT authorship contribution statement

Alexander Toet: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jan B.F. Van Erp:** Formal analysis, Methodology, Writing – review & editing. **Erik Van der Burg:** Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation.

Declaration of competing interest

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

Data availability

The link to the data is mentioned in the manuscript.

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