Measurement of food-related approach–avoidance biases: Larger biases when food stimuli are task relevant

Anja Lender, Adrian Meule, Mike Rinck, Timo Brockmeyer, Jens Blechert

Abstract

Strong implicit responses to food have evolved to avoid energy depletion but contribute to overeating in today’s affluent environments. The Approach–Avoidance Task (AAT) supposedly assesses implicit biases in response to food stimuli: Participants push pictures on a monitor “away” or pull them “near” with a joystick that controls a corresponding image zoom. One version of the task couples movement direction with image content-independent features, for example, pulling blue-framed images and pushing green-framed images regardless of content (‘irrelevant feature version’). However, participants might selectively attend to this feature and ignore image content and, thus, such a task setup might underestimate existing biases. The present study tested this attention account by comparing two irrelevant feature versions of the task with either a more peripheral (image frame color: green vs. blue) or central (small circle vs. cross overlaid over the image content) image feature as response instruction to a ‘relevant feature version’, in which participants responded to the image content, thus making it impossible to ignore that content. Images of chocolate-containing foods and of objects were used, and several trait and state measures were acquired to validate the obtained biases. Results revealed a robust approach bias towards food only in the relevant feature condition. Interestingly, a positive correlation with state chocolate craving during the task was found when all three conditions were combined, indicative of criterion validity of all three versions. However, no correlations were found with trait chocolate craving. Results provide a strong case for the relevant feature version of the AAT for bias measurement. They also point to several methodological avenues for future research around selective attention in the irrelevant versions and task validity regarding trait vs. state variables.

© 2018 Elsevier Ltd. All rights reserved.

1. Introduction

Fast automatic action tendencies (i.e., an approach bias) towards unhealthy substances (e.g., alcohol, drugs, high calorie food) might play a significant role in craving for and consumption of these substances (Krieglmeyer, Deutsch, Houwer, & Raedt, 2010; Wiers et al., 2007). Presumably resulting from classical and operant conditioning processes, food cues can elicit strong approach behavior (Berridge, 2009; Jansen, 1998), which may contribute to increased food intake, and might thus also contribute to symptoms of eating and weight disorders (Brockmeyer, Hahn, Reetz, Schmidt,

& Friederich, 2015a; Havermans, Giesen, Houben, & Jansen, 2011). According to dual process models, such automatic responses to food cues operate in an impulsive information processing system and are thus characterized by being rapid and difficult to govern by deliberate action (Bechara, 2005; Wiers, Gladwin, Hofmann, Sailemnik, & Ridderinkhof, 2013).

These automatic action tendencies towards cues of unhealthy substances have been measured by reaction time tasks such as the Approach–Avoidance Task (AAT). The AAT involves moving a stimulus on the computer screen either closer to oneself by pulling a joystick towards oneself or away from oneself by pushing the joystick away from oneself. To reinforce the meaning of joystick moves, one form of the AAT involves corresponding image zooms in response to joystick movements: the image grows for pull movements and shrinks for push movements. Each image type (e.g., food

https://doi.org/10.1016/j.appet.2018.01.032
0195-6663/© 2018 Elsevier Ltd. All rights reserved.
images and object images) is pulled on half of the trials and pushed on the other half of the trials. An approach bias is inferred if one picture type (e.g., food) is pulled faster than pushed (the same comparison for a control category controls for unspecific effects, e.g., that pull movements are generally faster). Two types of instructions have been used to let the participant know which images/trials to pull and which to push. In the irrelevant feature version, image content is irrelevant for the direction of joystick movements and participants respond to an content-independent feature (irrelevant feature versions are also sometimes termed ‘implicit’ or ‘non-conscious’). For example, they might be instructed to pull pictures with a blue line (regardless of content) and to push pictures with a green frame (regardless of content). In the relevant feature version, image content is the relevant feature: participants are required to classify the actual content of the picture to determine joystick movement direction (e.g., push joystick for food images, pull joystick for non-food images). Hence, the main difference between both task versions is where the participants’ attention is directed: towards picture content (and categories, e.g., food vs. objects) or towards an image-irrelevant feature like frame color.

Irrelevant feature versions of the AAT are thought to minimize demand charactersitics and to measure more implicit/automatic responses because a conscious evaluation of the picture content is avoided (Rinck & Becker, 2007). This version also allows for a flexible handling of contingencies: the ‘standard’ measurement of approach/avoidance bias requires that 50% of each stimulus class is pulled and 50% pushed. This contingency is changed in approach–avoidance training, to contradict both versions directly. Using alcohol-related stimuli, Rinck et al. (2015) found that the relevant feature AAT version of the AAT, the lack of a picture-independent, irrelevant response criterion requires repeated reversals of instructions (e.g., 80 trials of pulling foods and pushing objects alternating with 20 trials of pushing foods and pulling objects) and, therefore, requires relearning.

Thus, the majority of studies using the ‘zoom AAT’—at least in the context of food or craved substances—relied on the irrelevant feature AAT version. However, this is in contrast with findings from a meta-analysis, which showed that the relevant feature AAT produces much stronger bias measures than the irrelevant AAT version (Phaf, Mohr, Rotteveel, & Wicherts, 2014). While this meta-analysis compared findings from different studies, only few studies have contrasted both versions directly. Using alcohol-related stimuli, Kersbergen, Woud, and Field (2015) found that the relevant feature AAT—but not the irrelevant feature AAT—was predictive of alcohol consumption. The relevant feature AAT directs the participants’ attention to the stimuli whereas the irrelevant feature AAT directs participants’ attention to the answer criterion signaling push or pull and, thus, creates competition between the two. The wider literature on whether emotional stimuli automatically capture attention is inconclusive: while the majority of studies show that emotional stimuli capture attention, many studies have also demonstrated effects of top-down (i.e., not stimulus driven) attention: when the task directs attention away from emotional stimuli (or when the competing task is very difficult) attentional capture effects decrease or disappear (Carretie, 2014). This is consistent with a limited capacity view on attention and it seems that biologically salient stimuli are not fully exempt from that.

Against that background, the present study compared relevant and irrelevant feature versions of the AAT in the food context. In the relevant feature AAT version, participants had to pull or push a joystick depending on whether the picture displayed chocolate-containing food or non-edible objects (content AAT condition). To gain more information specifically on the role of attention to food stimuli as opposed to response feature, we also implemented an irrelevant feature AAT condition, where participants responded to frame colors of the images (frame AAT condition) and an ‘attention enhanced’ condition in which the response feature was directly overlaid over the images (symbol AAT condition). In the latter condition, participants responded to small circles and crosses centered on the image (e.g., pull images with a circle, push images with a cross). Thus, while spatial attention could focus away from image content in the frame AAT condition, this was difficult in the symbol AAT condition. In addition, to gain knowledge on the criterion validity of the different versions of the AAT, auxiliary validation data were collected: besides state and trait chocolate craving, salivary flow during a chocolate exposure and actual chocolate consumption were measured as proxies for approach motivation towards chocolate. Differential correlations of these validation data with AAT biases in the three conditions could thus speak to their relative validity. Based on Phaf et al. (2014), we expected the largest AAT bias in the content AAT condition, followed by the symbol AAT and the frame AAT condition. Furthermore, based on Kersbergen et al. (2015), we also expected correlations with other appetitive behaviors (craving, salivation, consumption) to rank in that order, that is, the strongest associations were expected in the content AAT condition, followed by the symbol AAT and the frame AAT condition. Particularly state craving increases across the task might correlate with the AAT bias (Brockmeyer, Hahn, Reetz, Schmidt, & Friederich, 2015b). We also explored correlations in the whole sample between the AAT bias and appetitive behaviors to determine overall validity.

2. Methods

2.1. Participants

The study was approved by the institutional review board of the University of Salzburg. We recruited 117 individuals from university students and the general community in Salzburg, Austria. Participation was compensated with either course credit or € 10. Data from 13 participants were excluded due to technical problems (n = 4), non-adherence to or misunderstanding of task instructions (n = 8), and a high number of errors (n = 1) (>35 incorrect trials; cf. Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011), leaving a final sample size of n = 104 participants (81.7% female, n = 85). Mean age was M = 23.2 years (SD = 6.02, Range: 17–50) and mean body mass index (BMI) was M = 21.7 kg/m² (SD = 2.71, Range: 15.2–34.9). Thirty-five participants (33.7%) self-identified as current dieters.

2.2. Materials

2.2.1. Approach–Avoidance Task (AAT)

The AAT included 16 pictures of chocolate-containing foods and 16 pictures of non-edible objects, which were obtained from the food-pics database (Blechert, Meule, Busch, & Ohla, 2014). Chocolate and object pictures were matched with regard to their color (RGB), size, brightness, contrast, complexity, recognizability, and familiarity. Each picture had a resolution of 96 dpi (619 × 469 pixels) and was edited to have four different versions: either a cross or a circle was superimposed in the center of the picture and the picture was framed by either a blue or green line (Fig. 1).

1. BMI data missing for one participant.
Participants were randomly assigned to one of three conditions, differing by which image feature to respond to by either pulling or pushing a joystick (Attack™ 3, Logitech Europe S.A., Lausanne, Switzerland) to enlarge (zoom-in) or shrink (zoom-out) image size. In the frame AAT condition, participants were instructed to respond to the feature picture frame color (blue vs. green frame, e.g., push blue, pull green). In the symbol AAT condition, response criterion was the symbol in the center of the picture (cross vs. circle, e.g., push cross, pull circle). In the content AAT condition, participants were instructed to respond to the content of the image (food vs. objects). As the content AAT condition required a mid-task instruction switch (e.g., push objects, pull food switches to push food, pull objects), analog instruction switches were imposed on the indirect conditions to increase the comparability of conditions (the order of instruction blocks was counterbalanced across participants).3

The task, presented with E-Prime 2.0 Professional (Psychology Software Tools, Inc., Sharpsburg, PA, USA), comprised two instruction blocks, each presenting 128 trials of 4 × 16 food and 4 × 16 object images in individually randomized order, totaling in 2 × 128 = 256 trials for the whole task. Thus, each instruction block contained balanced trial numbers regarding frame color (50% blue, 50% green), center symbol (50% cross, 50% circle), and image content (50% food, 50% objects), and, thus, triggered 50% push and 50% pull movements. Trials were separated by a jittered interstimulus interval (400 and 591 ms).

2.2.2. Chocolate version of the Food Cravings Questionnaire-Trait-reduced (FCQ-T-r)

The 15-item German chocolate version of the FCQ-T-r (Meule & Hormes, 2015) was used for measuring the frequency and intensity of chocolate cravings in general. Response categories range from never/not applicable to always and are scored with 1–6. Thus, total scores can range between 15 and 90 with higher scores indicating more frequent and intense chocolate cravings. Internal consistency was α = .931 in the current study.

2.2.3. Chocolate version of the Food Cravings Questionnaire-State (FCQ-S)

The 15-item German chocolate version of the FCQ-S (Meule & Hormes, 2015) was used for measuring the intensity of current chocolate craving (12 items) and hunger (3 items). Response categories range from strongly disagree to strongly agree and are scored with 1–5. Thus, scores of the chocolate craving subscale can range between 12 and 60 and scores of the hunger subscale can range between 3 and 15. Higher scores indicate more intense current chocolate craving and more intense current hunger, respectively. Internal consistencies ranged between α = .904 and .923 for the chocolate craving subscale and between α = .864 and .904 for the hunger subscale in the current study.

2.2.4. Chocolate bars

Five different types (Milk chocolate with butter biscuit, milk chocolate with hazelnuts, milk chocolate with yogurt, dark chocolate, alpine milk chocolate) of 100 g chocolate bars (Ritter Sport, Alfred Ritter GmbH & Co. KG, Waldenbuch, Germany) were used for chocolate exposure and consumption.

2.2.5. Dental roles

Cotton dental roles (8 × 38 mm, Celluron®, Paul Hartmann AG, Heidenheim, Germany) were used for measuring salivary flow.

2.2.6. Weighing scales

The chocolate was weighed with a micro scale with 1 g precision (Page, Soehnle/Leifheit AG, Nassau, Germany) and the dental rolls were weighed with a micro scale with 0.01 g precision (VOLT-CRAFT® PS-200HTP, Conrad Electronic SE, Hirschau, Germany).

2.2.7. Sociodemographic and anthropometric information

Participants indicated their sex (male/female), age (years), height (m), and body weight (kg). Current dieting status (yes/no) was assessed with the question “Are you currently restricting your food intake to control your weight (e.g., by eating less or avoiding certain foods)?” (cf. Meule, Lutz, Vögele, & Kübler, 2012).

---

3 No significant order effects were found in any of the conditions.
2.3. Procedure

Participants completed an online questionnaire, which included the FCQ-T-R, via www.unipark.com at least three days before the laboratory testing. In the laboratory session, participants were tested individually. After reading and signing informed consent, they completed the FCQ-S for the first time (FCQ-S1). Next, participants were placed in front of a laptop in a comfortable position to handle the joystick with their dominant hand and then performed the AAT. After finishing the AAT, they completed the FCQ-S for the second time (FCQ-S2).

To standardize measurement of baseline salivary flow, participants were asked to take at least one sip of water or as many as needed to quench their thirst. Next, the experimenter handed out three dental rolls and instructed participants to place two between their lower gums and cheeks and one under the tongue. After 90 s of baseline, the experimenter instructed participants to remove the dental rolls and put them in a plastic cup and, again, to take at least one sip of water. Following this, five sorts of chocolate bars were placed in front of the participants and they were instructed to choose the one they liked the most at that moment. Participants were then again instructed to place three dental rolls between their lower gums and cheeks and under the tongue for reactivity measurement, and, subsequently, to unwrap the chocolate, to snap off one piece with their fingers, and to smell but not eat it. After 90 s, the experimenter again instructed participants to remove the dental rolls and put them in a plastic cup. Participants then completed the FCQ-S for the third time (FCQ-S3).

Participants were then told that they could now eat as much of the remaining chocolate bar as they wished during completion of the final set of questionnaires, which assessed sociodemographic and anthropometric information, among others. During questionnaire completion, the experimenter left the participant unobserved and returned after ten minutes. Finally, the dental rolls and the remaining chocolate were weighed.

2.4. Data analyses

As a randomization check, the three experimental conditions (frame AAT: n = 34, symbol AAT: n = 34, content AAT: n = 36) were compared regarding sex distribution and current dieting status with χ²-tests and regarding age, trait chocolate craving scores, state chocolate craving scores at baseline, and state hunger scores at baseline with one-way analyses of variance.

To examine correlates of AAT performance, an approach bias score was calculated by subtracting median reaction times of pull from push trials for each stimulus category and then subtracting the difference score for objects from the difference score for food (i.e., approach bias score = reaction time for pushing food — reaction time for pulling food — reaction time for pushing objects — reaction time for pulling objects). Thus, positive values indicate a relative approach bias towards chocolate-containing food, and negative values indicate a relative avoidance bias of chocolate-containing foods. This bias score was subjected to moderation analysis using the SPSS macro PROCESS (Hayes, 2013). Here, condition served as multi-categorical moderator (Hayes & Montoya, 2017) of the relationships between bias scores and appetitive behaviors. Furthermore, we explored correlations in all participants (i.e., when combining all three conditions). To do so, and to account for between-group differences in approach bias scores, we z-standardized the approach bias score within each of the three experimental conditions.

The following appetitive behaviors were tested: trait chocolate craving (FCQ-T-R scores), state chocolate craving and hunger, and their respective change score across AAT and chocolate exposure (ΔFCQ-S_AAT = FCQ-S2 — FCQ-S1, ΔFCQ_S_Exposure = FCQ-S3 — FCQ-S2, same logic for hunger), salivary flow (exposure — baseline), and chocolate consumption (initial weight — weight of the remaining chocolate). Thus, positive values generally indicate increased reactivity to the AAT or chocolate exposure.

3. Results

Across the three experimental conditions, participants did not differ in sex distribution (χ²(2,12) = 0.68, p = .714), age (F(2,101) = 1.12, p = .330), BMI (F(2,100) = 2.44, p = .093), current dieting (χ²(2) = 2.50, p = .287), trait chocolate craving scores (F(2,101) = 1.01, p = .367), state chocolate craving scores at baseline (F(2,101) = 2.90, p = .060), or state hunger scores at baseline (F(2,101) = 0.28, p = .755).

There were significant main effects of condition (frame vs. symbol vs. content), stimulus (food vs. objects), and movement (pull vs. push; all F(1,101) > 14.6, p < .001, n²p > .127) as well as significant two-way interactions condition × stimulus (F(2,101) = 14.0, p < .001, n²p = .217) and stimulus × movement (F(1,101) = 15.3, p < .001, n²p = .131). These effects were qualified by a significant three-way interaction condition × stimulus × movement (F(2,101) = 6.98, p < .001, n²p = .121). To follow up on the three-way interaction, the three conditions were analyzed separately. While the stimulus × movement interaction was not significant in the frame AAT and symbol AAT condition (all F(1,33) < 3.94, p > .055, n²p < .107), it was significant in the content AAT condition (F(1,35) = 14.1, p < .001, n²p = .287) meaning that only in this condition did push and pull movements differ for foods vs. objects. In fact, only in the content AAT condition did participants pull food stimuli faster than object stimuli (t(35) = 6.14, p < .001) while they pushed food and object stimuli equally fast (t(35) = 0.19, p = .853). Furthermore, participants pulled food stimuli faster than they pushed them (t(35) = 5.38, p < .001) while they pushed and pushed object stimuli equally fast (t(35) = 0.02, p = .981). Mean reaction times are displayed in Fig. 2.

Our validity research question asked for differences between the three task conditions in correlations with appetitive behaviors such as trait and state cravings, salivation and consumption. Moderation results indicated that condition did not moderate any of these relationships (for all interaction effects, R² change was < .031, all ps > .197). However, when exploring correlations in the whole group (collapsed across conditions), a higher z-standardized approach bias score correlated with higher state chocolate craving after the AAT (r(104) = .223, p = .023) and with higher increases of state chocolate craving during the AAT (r(104) = .245, p = .012; all other rs < .194, ps > .050).

4. Discussion

The present study was motivated by the lack of studies directly comparing relevant feature versions of the AAT (in which
Three accounts might explain this. First, in dual task experiments, in which top-down attention and stimulus-driven attention compete, emotional ‘distractors’ were shown to capture attention more so than neutral distractors. In that sense, our food images should have constituted an emotionally salient distractor. However, research has repeatedly shown that these attentional capture effects are reduced or even abolished when the foreground (top-down) task (here: symbol—cross vs. push—pull mapping) is difficult (reviewed in Carretie, 2014). Based on limited resource accounts of attention (Lavie, 1995), task-irrelevant distractors fall prey to a difficult foreground task, even when emotional. Second, research showed that distractor frequency in attentional capture studies affect interference with a foreground task: rare distractors (and thus more novel ones) capture attention more strongly than frequent ones. In our task, ‘distractors’ (images) were frequent, that is, present on every trial, thus potentially reducing their attention-grabbing effects. Third, habituation or repetition effects might have played a role. Our tasks involved 16 different chocolate images, which were repeated 8 times to generate the 256 trials. Repetition of identical stimuli has been shown to reduce behavioral interference in tasks with emotional distractors (Codispoti, De Cesarei, Biondi, & Ferrari, 2016). Yet, repetitions did not abolish compatibility effects in the content condition. However, as such relevant feature conditions are thought to involve evaluation of the stimulus as a whole (because image category is task-relevant and not image details) whereas compatibility effects in irrelevant feature conditions might be based on characteristics of the individual pictures, such repetition effects might differ by condition (de Houwer, 2013). Future research could follow up on this by varying image heterogeneity (i.e., higher number of images) and task difficulty systematically in irrelevant and relevant feature AAT versions.

While the results on bias size (called ‘task sensitivity’ by Krieglmeyer et al., 2010) were clear-cut, the results on validity were less so. We had included several additional measures—which are commonly used to assess appetitive responding and cue reactivity—to gain insight into the criterion validity of each of the task conditions. These correlations did not differ between groups (as revealed by non-significant moderations by condition). However, when conditions were combined, the AAT bias—corrected for between-group differences in size—positively correlated with higher state chocolate craving after the AAT and with higher increases of state chocolate craving during the AAT, in line with previous literature (Brockmeyer et al., 2015b). This suggests that task validity is independent of bias size, that is, the ‘ranking’ of participants on state craving relative to bias size was the same in each condition. This might suggest that only individuals with active state craving might have perceived the chocolate images in the
irrelevant feature conditions, whereas state craving potentiated attention in the relevant feature condition. In line with this possibility, we found that performance in a chocolate-specific Implicit Association Test was only indirectly associated with trait measures of chocolate craving through current chocolate craving and, in addition, only in hungry participants (Richard, Meule, & Blechert, in press). Thus, it seems that appetitive valence systems need to be activated and in a ‘hot state’ to detect task-irrelevant but state-congruent images and to subsequently generate (in)compatiblity effects with motor representations of approach or avoidance responses. Clearly, more research is needed here, contrasting experimentally induced state craving states in their effect on relevant vs. irrelevant feature AAT tasks.

In sum, the present results suggest that versions of the AAT that make images task-relevant (e.g., ‘push food, pull objects’) yield stronger biases—possibly due to the role of attention—and with open research questions regarding task difficulty and image repetition. More tentatively, both relevant feature and irrelevant feature versions of the task show some criterion validity in that AAT biases relate to higher state craving. Together, these results have the potential to open new avenues for applications of the AAT to relevant populations thought to be characterized by increased appetitive responding to food cues (e.g., food craving: Brockmeyer et al., 2015b), reduced appetitive responding (e.g., anorexia nervosa; Neimeijer, de Jong & Roefs, 2015; Paslaklis et al., 2016) or ambivalent responding (Hormes & Rozin, 2011; Rodríguez, Fernández, Cepeda-Benito, & Vila, 2005). It also poses crucial questions with regard to how AAT training protocols should be designed (Becker, Jostmann, Wiers, & Holland, 2015; Brockmeyer et al., 2015a; Kakoschke, Kemps, & Tiggemann, 2017; Wiers et al., 2011).

Acknowledgment
This work was supported by the European Research Council under the European Union’s Horizon 2020 research and innovation program (ERC-StG-2014 639445 NewEat).

References