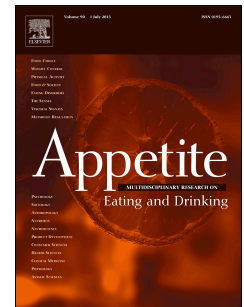# Accepted Manuscript

Approach–avoidance tendencies towards food: Measurement on a touchscreen and the role of attention and food craving

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Abstract

Automatic approach tendencies are often assessed with joystick-based approach–avoidance tasks (AATs). In line with similar studies, we have previously shown that individuals show an approach bias towards palatable food only when picture valence (i.e., the content of the picture) is relevant for task performance. In the current study, we adapted this joystick-based AAT for implementation on a touchscreen, which required participants to perform more naturalistic approach–avoidance movements. One-hundred and seven participants (73% female) were instructed to pull or push pictures of chocolate-containing food and non-edible objects either based on picture content (content group, $n = 36$), frame color (frame group, $n = 35$), or a symbol superimposed in the center of each picture (symbol group, $n = 36$). No approach bias towards food was detected in either group. However, trait chocolate craving and a general preference for chocolate related to higher approach bias scores only in the content group, but not in the frame or symbol group. In addition, only participants in the content group reported increases of current chocolate craving throughout the task. While this touchscreen-based AAT did not replicate results from its joystick-based equivalent, results are in line with suggestions that explicit task instructions may be preferred over implicit task instructions (i.e., when participants have to respond to valence-irrelevant features). Future studies may examine if and how touchscreen-based AATs can be implemented for modifying approach tendencies towards unhealthy food and, ultimately, reducing consumption of these foods.

Keywords

Approach–avoidance tendencies towards food: measurement on a touchscreen and the role of attention and food craving

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Introduction

Stimuli with a positive valence facilitate approach behavior while stimuli with a negative valence facilitate avoidance behavior (Solarz, 1960). Such approach–avoidance tendencies are usually assessed with computerized tasks. For example, joystick-based approach–avoidance tasks (AATs) are widely used. Here, participants are instructed to avoid certain stimuli by pushing a joystick and to approach certain stimuli by pulling a joystick (Rinck & Becker, 2007). These movements are usually accompanied by a visual zooming effect such that the picture shrinks when pushing the stimulus "away" and the picture enlarges when pulling the stimulus "towards" oneself. This zooming is thought to disambiguate the movement, that is, to clarify that joystick movements manipulate the virtual position of the stimulus and not the viewer's position. Approach (avoidance) tendencies are inferred from reaction times when participants are faster when pulling (pushing) than pushing (pulling) the target stimuli or when pull (push) movements in response to target stimuli are faster than the corresponding movements in response to control stimuli, respectively.

To make the task more implicit, participants are often instructed to respond to a stimulus property that is unrelated to stimulus valence. For example, participants may be required to pull pictures in portrait format and push pictures in landscape format while picture content (e.g., alcoholic vs. non-alcoholic beverages) is irrelevant for performing the task correctly (Wiers, Rinck, Kordts, Houben, & Strack, 2010). However, research as shown that approach–avoidance tendencies can be detected more reliably when the mapping rule is explicitly based on the relevant (e.g., disorder-related) than irrelevant stimulus feature (Kersbergen, Woud, & Field, 2015; Phaf, Mohr, Rotteveel, & Wicherts, 2014). In a study using pictures of palatable foods and non-edible objects, for example, we found that participants showed an approach bias towards food only when they were directly instructed to pull/push food/objects. Participants who responded to the very same pictures—but were

instructed to pull/push pictures depending on the frame color (blue vs. green) or superimposed symbols (cross vs. circle)—did not exhibit an approach bias towards food (Lender, Meule, Rinck, Brockmeyer, & Blechert, 2018).

Moreover, while joystick-based AATs represent established and relatively well-validated tools for measuring approach–avoidance tendencies (e.g., towards alcohol), a critical examination of existing studies suggests that food-related AATs produced rather mixed findings. Specifically, the majority of studies that used joystick-based AATs did not demonstrate an approach bias towards (high-calorie) food relative to reactions to control stimuli or found such a bias only in certain subgroups of participants (Brockmeyer, Hahn, Reetz, Schmidt, & Friederich, 2015; Kakoschke, Kemps, & Tiggemann, 2015; Maas, Keijsers, et al., 2017; Maas, Keijsers, Rinck, Tanis, & Becker, 2015; Maas, Woud, et al., 2017; Machulska, Zlomuzica, Adolph, Rinck, & Margraf, 2015; Paslakis, Kühn, Grunert, & Erim, 2017; Paslakis et al., 2016).

Amongst other explanations, one reason for these inconsistent findings may be that joystick movements do not mimic naturalistic approach and avoidance behaviors as the kinds of remote control operations afforded by joysticks represent a phylogenetically very recent development. Typical food intake settings feature reaching, grasping, and holding movements—included speeded and forceful pulling in case of competition for food. Thus, a laboratory implementation of a potentially evolutionarily shaped motor behavior should mimic such actions as close as possible.

As a first step in this direction, the current study examined the implementation of an AAT on a touchscreen monitor. For this, we adapted the task design of our previous study (Lender et al., 2018). Similar to that study, participants were either instructed to pull/push pictures of chocolate-containing foods and non-edible objects or were instructed to respond to valence-irrelevant features of these pictures. Yet, instead of moving a joystick, participants in

the present study were instructed to move the stimuli towards or away from themselves by sliding their dominant hand on a touchscreen—similar to actual hand movements that are required to move real items (Figure 1).

We expected to replicate results from our joystick-based AAT, that is, that participants would show an approach bias towards food only when instructed to respond to the content of the pictures, but not when instructed to respond to the irrelevant features. As previous joystick-based studies have found that a higher approach bias towards high-calorie foods relates to more frequent and intense food cravings in general (trait food craving) and stronger current food craving (Brockmeyer et al., 2015; Lender et al., 2018), we further expected that approach bias towards chocolate-containing foods would be associated with trait and state chocolate craving in the current study. Finally, we also explored whether approach bias towards chocolate-containing foods would be related to a general preference for chocolate (assessed through valence and palatability ratings of the food pictures) and whether performing the task would affect state chocolate craving and hunger differentially as a function of task instruction.

Methods

Participants

One-hundred and eleven individuals participated in this study. However, data of four participants had to be excluded from analyses.[1] Thus, the final sample comprised $n = 107$ participants (72.9% female, $n = 78$). Mean age was $M = 23.3$ years ($SD = 5.84$, Range: 18-50) and mean body mass index was $M = 22.4$ kg/m² ($SD = 3.11$, Range: 17.2– 34.6). According to the guidelines by the World Health Organization (2000), seven participants were underweight (6.50%), 84 participants had normal weight (78.5%), 12 participants were overweight (11.2%), and four participants were obese (3.70%). The majority of participants had German (60.7%, $n = 65$) or Austrian (38.3%, $n = 41$) citizenship, were university students (89.7%, $n = $

96), and were right-handed (92.5%, $n = 99$). Twenty-five participants (23.4%) indicated that they were currently restricting their food intake to control their weight and 70 participants (65.4%) indicated that they did so in the past.

Measures and materials

Sociodemographic and anthropometric data. Participants indicated their sex, age, body height and weight, nationality, occupation, and handedness. They also indicated whether they were currently dieting or had dieted in the past by answering (yes/no) the questions "Are you currently restricting your food intake to control your weight (e.g., by eating less or avoiding certain foods)?" and "Have you ever restricted your food intake to control your weight in the past (e.g., by eating less or avoiding certain foods)?".

Approach–avoidance task (AAT). The AAT included 16 pictures displaying chocolate-containing foods and 16 pictures displaying non-edible objects, which were obtained from the food-pics database (Blechert, Meule, Busch, & Ohla, 2014).[2] Food and objects pictures did not differ in color, size, brightness, contrast, complexity, recognizability, and familiarity (all $t_{(30)} < 1.27$, $p > .22$). 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. These pictures have been previously used in a joystick-based AAT (Lender et al., 2018) and can also be found in the supplementary material. In contrast to the joystick-based AAT, however, picture size did not change, that is, we did not employ a zooming effect because of the naturally occurring distance change in the current study.

The task was programmed in unity (https://unity3d.com) and displayed on a 23-inch iiyama ProLite T2336MSC-B2 touchscreen monitor with a resolution 1920×1080 pixels. It consisted of two blocks, in each of which each picture was presented once (i.e., 16×4 food

pictures and 16×4 object pictures), totaling $2 \times 128 = 256$ trials. Because of this arrangement, the number of images within each block were balanced regarding color of the frame (50% blue, 50% green), the symbol in the center of the picture (50% cross, 50% circle) and image content (50% food, 50% objects). Within each block, the order of picture presentations was randomized.

Participants were assigned to one of three groups, in each of which they had to respond to one image property by moving the picture to the bottom of the screen (towards themselves = pull) and to respond to another image property by moving the picture to the top of the screen (away from themselves = push; Figure 1). Participants in the *content* group were instructed to respond to the content of the image (food vs. non-edible object). Participants in the *frame* group were instructed to respond to the color of the picture frame (blue vs. green). Participants in the *symbol* group were instructed to respond to the symbol in the center of the picture (cross vs. circle). After the first block, the instructions (e.g., pull food, push objects) were reversed (e.g., push food, pull objects). Because of this instruction shift, food and objects were equally often approached (i.e., pulled) and avoided (i.e., pushed) in each of the three groups. The order of blocks was counterbalanced across participants.

Palatability ratings. Participants rated the food pictures by responding to the question "How palatable/tasty do you find the object on the picture?" on a seven-point scale anchored $1 = not\ at\ all$ to $7 = very\ much$. Internal reliability was $\alpha = .896$.

Valence ratings. Participants rated the food and objects pictures by responding to the question "How pleasant/appealing do you find the object on the picture?" on a seven-point scale anchored $1 = not\ at\ all$ to $7 = very\ much$. Internal reliabilities were $\alpha = .915$ (food) and $\alpha = .853$ (objects).

Food Cravings Questionnaire–Trait–reduced (FCQ–T–r). The German, chocolate-adapted version of the FCQ–T–r (Meule & Hormes, 2015) was used to measure the frequency and intensity of chocolate cravings in general. The scale has 15 items which are scored from 1 = *never* to 6 = *always*. Internal reliability was α = .941 in the current study.

Food Cravings Questionnaire–State (FCQ–S). The German, chocolate-adapted version of the FCQ–S (Meule & Hormes, 2015) was used to measure the intensity of current chocolate craving and hunger before and after the AAT. The scale has 15 items (12 items for the chocolate craving subscale and 3 items for the hunger subscale) which are scored from 1 = *strongly disagree* to 5 = *strongly agree*. Internal reliabilities of the craving subscale were α = .923 at baseline and α = .939 after the task. Internal reliabilities of the hunger subscale were α = .839 at baseline and α = .869 after the task.

Procedure

The study was approved by the institutional review board of the University of Salzburg. Participants were recruited at the University of Salzburg and through a local job advertisements website. A few days prior to the laboratory testing session, participants completed an online survey, which included the FCQ–T–r, picture ratings, and other questionnaires that are not reported here. In the laboratory testing session, participants signed informed consent, provided the sociodemographic and anthropometric information, and completed the FCQ–S. They then performed the AAT, which included a brief practice block at the beginning of the task consisting of six trials with neutral stimuli that were not used in the test blocks. Subsequently, they completed the FCQ–S again. Afterwards, participants completed other tasks that are not reported here. Participation lasted approximately one hour and was reimbursed with course credits or €10.

Data analyses

Randomization check. Groups were compared regarding sex, nationality, occupation, handedness, and current and past dieting with Fisher's Exact Tests and regarding age, body mass index, palatability and valence ratings, FCQ–T–r scores, and FCQ–S scores at baseline with analyses of variance. We additionally report Bayes Factors (BF_{10}), for which values >1 indicate support for the alternative hypothesis over the null hypothesis. Bayes Factors were determined with JASP version 0.9.1 (www.jasp-stats.org) using the default priors.

Reaction times. Reaction time was defined as the time that participants needed to move the picture 200 pixels after the picture had appeared in the center of the screen. This threshold corresponded to moving the picture approximately 2 inches/5 cm on the touchscreen monitor (i.e., approximately 10% of the touchscreen monitor height of 20 inches/60 cm). Trials in which participants moved the pictures in the wrong direction (beyond the 200 pixels threshold) and trials with a duration of more than three seconds were excluded from analyses (9.65% of all trials). The number of valid trials did not differ between groups (Kruskal–Wallis Test $p = .220$, $BF_{10} = 0.22$).

Bootstrapped split-half reliability estimates for each condition (pull food, push food, pull objects, push objects) were obtained using the *average* function of the R package *splithalf* (Parsons, 2018) performing 5000 random splits. Reliability estimates ranged between $r = .84$–.89 (Spearman–Brown-corrected $r_{sb} = .91$–.94) in the content group, between $r = .84$–.88 (Spearman–Brown-corrected $r_{sb} = .92$–.94) in the frame group, and between $r = .87$–.93 (Spearman–Brown-corrected $r_{sb} = .93$–.96) in the symbol group. To examine correlates of AAT performance, an approach bias score was calculated (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 an approach bias towards chocolate-containing food and negative values indicate an avoidance bias from chocolate-containing foods. For this approach bias score, reliability estimates using the *difference-of-*

difference function of *splithalf* were $r = .84$ (Spearman–Brown-corrected $r_{sb} = .92$) in the content group, $r = −.24$ (Spearman–Brown-corrected $r_{sb} = −.74$) in the frame group, and $r = −.14$ (Spearman–Brown-corrected $r_{sb} = −.47$) in the symbol group.

In line with joystick-based AAT studies (Rinck & Becker, 2007), median reaction times were calculated and were submitted to an analysis of variance for repeated measures with *group* (content vs. frame vs. symbol) as between-subjects factor, and *direction* (pull vs. push) and *stimulus* (food vs. objects) as within-subjects factors. We additionally report Baws Factors (*BF*), which are Inclusion Bayes Factors based on matched models, that is, they compare Bayes Factors of models that contain the effect to equivalent models stripped of the effect (Mathôt, 2017). Baws Factors were determined with JASP version 0.9.1 (www.jasp-stats.org) using the default priors.

Palatability ratings. To examine whether palatability ratings predicted approach bias scores as a function of group, a moderated linear regression model was calculated using PROCESS (Hayes, 2018) with palatability ratings as independent variable (mean-centered), group as multicategorical moderator (using indicator coding; 0 = content group), and approach bias scores as dependent variable.

Valence ratings. Differences in valence ratings for food and objects pictures were tested with a paired *t*-test. To examine whether valence ratings of the food pictures predicted approach bias scores as a function of group, a moderated linear regression model was calculated that paralleled the model for palatability ratings, except that valence ratings of the objects pictures were additionally entered as covariate.

Trait chocolate craving. To examine whether trait chocolate craving predicted approach bias scores as a function of group, a moderated linear regression model was calculated that paralleled the model for palatability ratings.

State chocolate craving. Increases in state chocolate craving throughout the task as a function of group were tested with an analysis of variance for repeated measures with *group* (content vs. frame vs. symbol) as between-subjects factor, *measurement* (baseline vs. after the task) as within-subjects factor, and FCQ–S craving subscale scores as dependent variable. To examine whether state chocolate craving at baseline predicted approach bias scores as a function of group, a moderated linear regression model was calculated that paralleled the models for palatability ratings and trait chocolate craving described above. A further moderation model tested whether approach bias scores predicted state chocolate craving after the task as a function of group while controlling for state chocolate craving at baseline.

Hunger. Analyses with the FCQ–S hunger subscale paralleled those for the FCQ–S craving subscale.

Results

Randomization check

Groups did not differ in sex, age, body mass index, nationality, occupation, handedness, current and past dieting, palatability and valence ratings, trait chocolate craving, and state chocolate craving and hunger at baseline (Table 1).

Reaction times

A main effect of *direction* ($F_{(1,104)} = 8.19$, $p = .005$, $\eta_p^2 = .073$, $BF = 4.19$) indicated that pull movements ($M = 607$ ms, $SD = 94.5$) were faster than push movements ($M = 615$ ms, $SD = 88.6$). Main effects of *group* ($F_{(2,104)} = 21.4$, $p < .001$, $\eta_p^2 = .291$, $BF = 443327$) and *stimulus* ($F_{(1,104)} = 27.7$, $p < .001$, $\eta_p^2 = .210$, $BF = 56.2$) were qualified by a significant *group* $\times$ *stimulus* interaction ($F_{(2,104)} = 40.6$, $p < .001$, $\eta_p^2 = .438$, $BF = 8626000$). In the content group, participants reacted faster to food ($M = 649$ ms, $SD = 75.6$) than to objects ($M = 687$ ms, $SD = 80.9$; $t_{(35)} = 8.45$, $p < .001$, $d = .471$, $BF_{10} = 19480000$). In the frame group, reaction

times to food and objects did not differ from each other ($t_{(34)} = 1.54$, $p = .134$, $d = .073$, $BF_{10} = 0.53$). In the symbol group, participants reacted faster to objects ($M = 609$ ms, $SD = 88.9$) than to food ($M = 618$ ms, $SD = 86.1$, $t_{(35)} = 2.60$, $p = .013$, $d = .097$, $BF_{10} = 3.28$). The *direction × stimulus* interaction ($F_{(1,104)} = 1.94$, $p = .166$, $\eta_p^2 = .018$, $BF = 0.66$) and the hypothesized *group × direction × stimulus* interaction ($F_{(2,104)} = 0.49$, $p = .614$, $\eta_p^2 = .009$, $BF = 0.17$) were not significant. All means and standard deviations of reaction times are displayed in Table 2.

Palatability ratings

Mean palatability ratings of the food pictures were $M = 4.85$ ($SD = 1.04$, Range: 2.19–7.00). In the moderation model, the *group × palatability ratings* interaction was significant (R^2 change = .078, $p = .015$). Higher palatability ratings related to higher approach bias scores in the content group ($b = 39.8$, $SE = 12.1$, $p = .001$), but not in the frame ($b = −5.82$, $SE = 11.1$, $p = .602$) or symbol group ($b = −0.35$, $SE = 12.3$, $p = .978$; Figure 2A).

Valence ratings

Participants rated the food pictures ($M = 4.76$, $SD = 1.05$) as more positive than the objects pictures ($M = 3.55$, $SD = 0.89$; $t_{(106)} = 9.29$, $p < .001$, $d = 1.24$, $BF_{10} = 2.937e+12$). In the moderation model, the *group × valence ratings* interaction was significant (R^2 change = .088, $p = .008$). Higher valence ratings of the food pictures related to higher approach bias scores in the content group ($b = 41.0$, $SE = 11.5$, $p < .001$), but not in the frame ($b = −5.75$, $SE = 11.8$, $p = .628$) or symbol group ($b = −2.03$, $SE = 11.1$, $p = .856$; Figure 2B).

Trait chocolate craving

Mean scores on the FCQ–T–r were $M = 35.3$ ($SD = 13.9$, Range: 15–86). In the moderation model, the *group × trait chocolate craving* interaction was significant (R^2 change = .085, $p = .009$). Higher FCQ–T–r scores related to higher approach bias scores in the

content group ($b = 2.75$, $SE = 0.75$, $p < .001$), but not in the frame ($b = -0.62$, $SE = 0.84$, $p = .462$) or symbol group ($b = 0.04$, $SE = 1.15$, $p = .970$; Figure 2C).

State chocolate craving

In the analysis of variance, the *group* × *measurement* interaction was marginally significant ($F_{(2,104)} = 3.01$, $p = .053$, $\eta_p{}^2 = .055$, $BF = 1.19$). In the content group, state chocolate craving scores increased from baseline ($M = 23.7$, $SD = 9.65$) to after the task ($M = 25.1$, $SD = 10.8$; $t_{(35)} = 2.13$, $p = .040$, $d = .131$, $BF_{10} = 1.32$). State chocolate craving scores did not change significantly in the frame group ($t_{(34)} = 1.11$, $p = .273$, $d = .109$, $BF_{10} = 0.32$) and in the symbol group ($t_{(35)} = 1.58$, $p = .122$, $d = .106$, $BF_{10} = 0.56$). The main effects of *group* ($F_{(2,104)} = 0.68$, $p = .507$, $\eta_p{}^2 = .013$, $BF = 0.47$) and *measurement* ($F_{(1,104)} = 1.40$, $p = .240$, $\eta_p{}^2 = .013$, $BF = 0.30$) were not significant. In the moderation models, state chocolate craving at baseline did not predict approach bias scores as a function of group (R^2 change = .022, $p = .326$) and approach bias scores did not predict state chocolate craving after the task as a function of group (R^2 change = .0003, $p = .920$).

Hunger

In the analysis of variance, a main effect of *measurement* ($F_{(1,104)} = 18.2$, $p < .001$, $\eta_p{}^2 = .149$, $BF = 391$) indicated that hunger increased from baseline ($M = 7.32$, $SD = 3.02$) to after the task ($M = 7.80$, $SD = 3.07$). The main effect of *group* ($F_{(2,104)} = 0.49$, $p = .611$, $\eta_p{}^2 = .009$, $BF = 0.52$) and the interaction *group* × *measurement* ($F_{(2,104)} = 1.09$, $p = .339$, $\eta_p{}^2 = .021$, $BF = 0.20$) were not significant. In the moderation models, hunger at baseline did not predict approach bias scores as a function of group (R^2 change = .035, $p = .161$) and approach bias scores did not predict hunger after the task as a function of group (R^2 change = .003, $p = .388$).

Discussion

The current study aimed at translating a joystick-based AAT to a touchscreen-based AAT for the assessment of approach tendencies towards food. The task had high internal reliabilities (Parsons, Kruijt, & Fox, 2018) and—in line with previous findings with joystick movements (Lender et al., 2018)—a main effect of direction was found such that pull (i.e., approach) movements were faster than push (i.e., avoid) movements. In contrast to our previous study, however, no approach bias towards food was found in either group. In the content group, participants reacted faster to food than to objects, but these reactions were independent of the type of movement (i.e., pull vs. push).

Although the finding of an approach bias towards food in the content group could not be replicated in the present adaptation for a touchscreen, we did find differential effects as a function of group that support validity of our design. In line with previous findings (Brockmeyer et al., 2015), higher trait chocolate craving related to higher approach bias towards chocolate-containing food (and, in fact, those with low trait chocolate craving showed an avoidance bias for chocolate-containing food). Thus, it appears that a more robust approach bias towards high-calorie foods can be found in certain subgroups of individuals (e.g., those with high trait food craving) while food approach tendencies can only be detected inconsistently in the general population.

The association between approach bias towards food and trait chocolate craving, however, was only found for individuals for which the content of the picture was relevant to the task (i.e., in the content group). This was further corroborated by similar associations with a general preference for these foods (i.e., palatability and valence ratings). Importantly, only approach bias scores in the content group proved to be reliable while internal reliability was unacceptable in the frame and symbol groups. Thus, we would argue that although the present results do not represent a direct replication of previous joystick-based studies, they are in line with results showing that instructions that make image valence task relevant seem to produce

more reliable detection of approach tendencies and their correlates (Kersbergen et al., 2015; Lender et al., 2018; Phaf et al., 2014).

The auxiliary finding that state chocolate craving only increased in the content group, but not in the other groups, supports these observations. The lack of craving induction and of finding an approach bias (or respective correlations with trait chocolate craving) in the irrelevant task instruction conditions (in which participants attended to either frame colors or to overlaid symbols) point to the relevance of selective attention. Specifically, it seems that participants were able to successfully ignore picture contents and single out task cues (i.e., frames and symbols) in the service of efficient task performance. This again favors the use of relevant over irrelevant task instructions and dovetails with the ongoing debate on whether emotional material generally captures attention automatically or whether some degree of attention to the images is necessary for an observation of the downstream emotion-related processing bias (Carretié, 2014). Yet, neither momentary craving and hunger before the task nor task-induced craving and hunger increases were associated with approach bias scores in the content group. Given the associations found between approach bias and trait chocolate craving as well as palatability/valence ratings, this might suggest that correlates of approach–avoidance biases are more trait-like in nature and reflect overlearned stimulus–response associations rather than momentary oscillations in motivational state. Thus, future research is necessary that clarifies the relationships between trait and state food craving and approach tendencies towards food.

While the current findings indicate that our touchscreen-based paradigm is a valid measure of food-related approach bias, further studies may test whether the current paradigm can be generalized for measuring approach–avoidance biases to other stimulus classes and in other samples as well (e.g., approach bias to alcoholic beverages in heavy drinkers or to smoking stimuli in smokers). In addition, the current sample consisted of predominantly

normal-weight women and group sizes were moderate. Thus, replication of the current results in larger and more representative samples is needed. Another future avenue would be to investigate the current paradigm in relevant clinical samples such as individuals with eating disorders and obesity. Furthermore, while subjective ratings of chocolate liking and craving provide support for validity of our task, future research need to include validation criteria other than self-report (e.g., actual food consumption). Finally, given that current food-related approach–avoidance trainings do not reliably change eating behavior (Aulbach, Knittle, & Haukkala, in press), future studies may examine the use of our more naturalistic touchscreen paradigm for modifying approach bias towards food and food consumption.

In conclusion, the current results are partially in line with previous joystick-based AAT studies and associations with approach bias-relevant constructs such as trait chocolate craving support validity of our touchscreen-based AAT. Future research may examine if and how such a touchscreen-based AAT may be employed as an approach bias modification training for reducing consumption of appetitive substances.

Footnotes

[1]Two participants had to be excluded due to technical difficulties (program hang for one participant and failure to produce a valid output file for another participant). Data of one participant contained only two valid trials. One participant had a conspicuously fast median reaction time in the second block (210 ms for pulling objects, 254 ms for pushing food). Thus, we excluded data from this participant because reaction times of all other participants in each of the four conditions were slower than 400 ms. Furthermore, these reaction times resulted in an approach bias score of −710 ms while scores ranged between −391 and 273 ms for all other participants.

[2]Picture numbers in the food-pics database: 004, 079, 107, 111, 137, 140, 162, 163, 165, 168, 189, 286, 289, 465, 500, 510 (chocolate pictures); 1004, 1015, 1045, 1056, 1059, 1095, 1146, 1188, 1212, 1226, 1227, 1260, 1265, 1279, 1283, 1293 (neutral pictures).

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Table 1

Participant characteristics as a function of group

$N = 107$	Content group ($n = 36$)	Frame group ($n = 35$)	Symbol group ($n = 36$)	Test statistics
Sex (female)	$n = 26$ (72.2%)	$n = 28$ (80.0%)	$n = 24$ (66.7%)	$\chi^2 = 1.61$, $p = .482$, $\phi = .123$, $BF_{10} = 0.23$
Age (years)	$M = 23.1$ ($SD = 4.96$)	$M = 24.0$ ($SD = 7.14$)	$M = 22.9$ ($SD = 5.34$)	$F_{(2,104)} = 0.34$, $p = .711$, $\eta_p^2 = .007$, $BF_{10} = 0.12$
Body mass index (kg/m²)	$M = 21.8$ ($SD = 2.33$)	$M = 22.9$ ($SD = 3.74$)	$M = 22.4$ ($SD = 3.11$)	$F_{(2,104)} = 1.12$, $p = .331$, $\eta_p^2 = .021$, $BF_{10} = 0.22$
Nationality (German)	$n = 24$ (66.7%)	$n = 21$ (60.0%)	$n = 20$ (60.7%)	$\chi^2 = 3.14$, $p = .529$, $\phi = .175$, $BF_{10} = 0.17$
Occupation (Students)	$n = 30$ (83.3%)	$n = 32$ (91.4%)	$n = 34$ (94.4%)	$\chi^2 = 5.93$, $p = .740$, $\phi = .243$, $BF_{10} = 0.32$
Handedness (right-handed)	$n = 33$ (91.7%)	$n = 31$ (88.6%)	$n = 35$ (97.2%)	$\chi^2 = 1.99$, $p = .352$, $\phi = .136$, $BF_{10} = 0.63$
Currently dieting (yes)	$n = 8$ (22.2%)	$n = 9$ (25.7%)	$n = 8$ (22.2%)	$\chi^2 = 0.21$, $p = .919$, $\phi = .039$, $BF_{10} = 0.12$
Past dieting (yes)	$n = 22$ (61.1%)	$n = 24$ (68.6%)	$n = 24$ (66.7%)	$\chi^2 = 0.50$, $p = .819$, $\phi = .067$, $BF_{10} = 0.12$
Palatability ratings (food)	$M = 4.88$ ($SD = 1.01$)	$M = 4.67$ ($SD = 1.11$)	$M = 5.01$ ($SD = 0.99$)	$F_{(2,104)} = 0.94$, $p = .395$, $\eta_p^2 = .018$, $BF_{10} = 0.19$
Valence ratings (food)	$M = 4.82$ ($SD = 1.05$)	$M = 4.69$ ($SD = 1.04$)	$M = 4.76$ ($SD = 1.09$)	$F_{(2,104)} = 0.14$, $p = .871$, $\eta_p^2 = .003$, $BF_{10} = 0.10$
Valence ratings (objects)	$M = 3.52$ ($SD = 0.87$)	$M = 3.52$ ($SD = 1.05$)	$M = 3.61$ ($SD = 0.74$)	$F_{(2,104)} = 0.12$, $p = .884$, $\eta_p^2 = .002$, $BF_{10} = 0.10$
Food Cravings Questionnaire–Trait–reduced (chocolate version)	$M = 38.1$ ($SD = 16.0$)	$M = 33.8$ ($SD = 14.5$)	$M = 34.1$ ($SD = 10.4$)	$F_{(2,104)} = 1.09$, $p = .340$, $\eta_p^2 = .021$, $BF_{10} = 0.21$
Food Cravings Questionnaire–State (chocolate craving subscale)	$M = 23.7$ ($SD = 9.65$)	$M = 25.3$ ($SD = 8.07$)	$M = 26.2$ ($SD = 8.03$)	$F_{(2,104)} = 0.80$, $p = .454$, $\eta_p^2 = .015$, $BF_{10} = 0.17$
Food Cravings Questionnaire–State (hunger subscale)	$M = 6.97$ ($SD = 3.52$)	$M = 7.54$ ($SD = 2.84$)	$M = 7.44$ ($SD = 2.68$)	$F_{(2,104)} = 0.36$, $p = .698$, $\eta_p^2 = .007$, $BF_{10} = 0.12$

Table 2

Means and standard deviations of reaction times (in ms) as a function of group, direction, and stimulus

	pull				push			
	food		objects		food		objects	
	M	SD	M	SD	M	SD	M	SD
Content group (n = 36)	653	93.7	681	87.0	645	77.9	692	83.6
Frame group (n = 35)	540	64.0	545	68.8	552	63.1	558	73.2
Symbol group (n = 36)	616	89.6	602	87.8	620	85.4	617	91.3

Figure captions

Figure 1. Experimental setup. (A) Participants sat in front of a table on which a touchscreen monitor was positioned in portrait orientation with an angle of approximately 20°. (B) Each trial began with display of a hand symbol in the center of the screen. When participants touched this symbol with five fingers, a picture appeared beneath their hand. Participants were instructed to move the stimulus away from or towards themselves, depending on the content of the picture (content group), color of the frame (frame group), or symbol in the middle of the picture (symbol group). The picture disappeared and the next trial started when the picture reached the correct border of the screen.

Figure 2. Simple slopes probing the interaction between group and palatability ratings of the food pictures (A), between group and valence ratings of the food pictures (B), and between group and scores on the chocolate version of the Food Cravings Questionnaire–Trait–reduced (C) when predicting approach bias scores. Positive, significant associations between the independent variables and approach bias scores only emerged in the content group, but not in the frame or symbol group.

A

B

| Start signal appears in the middle of the screen | Trial starts when subject touches the symbol | Stimulus appears on the screen | Subject moves stimulus up or down | Trial completed when picture reaches border |