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Retraining of automatic action tendencies in individuals with obesity: A randomized controlled trial

Hannah Ferentzi[a,1], Hannah Scheibner[b,1], Reinout Wiers[b], Eni S. Becker[a], Johannes Lindenmeyer[c], Sylvia Beisel[c], Mike Rinck[a,*]

[a] Behavioural Science Institute, Radboud University Nijmegen, The Netherlands
[b] University of Amsterdam, The Netherlands
[c] Salus Clinic Lindow, Germany

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ABSTRACT

Obesity is a major health concern, characterized by an automatically activated tendency to (over)-eat. Recent research suggests that an effective way to counteract automatic approach tendencies in unhealthy consumption behavior might be approach bias modification. Therefore, we investigated an approach-avoidance training for unhealthy food cues in 189 patients with obesity of a psychosomatic inpatient clinic who were participating in a nutrition advice program. Patients in the active training group were trained to make avoidance movements (pushing a joystick) in response to unhealthy food pictures and approach movements (pulling the joystick) in response to positive pictures, while the control group received sham training (approaching and avoiding both picture types). Approach-avoidance bias, body mass index, eating pathology and food-specific implicit associations were assessed before and after the training. In line with our hypothesis, approach-avoidance bias improved in the active training group after the training, in comparison to the sham training group. Moreover, this effect generalized to new, untrained stimuli. However, no effects of the training were found in a food-specific Single-Target Implicit Association Test, or on eating pathology questionnaires or body mass index. While the training results are promising, the effect of approach-avoidance bias modification on relevant behavior in obesity has yet to be established before it may be implemented as an add-on treatment.

1. Introduction

Obesity, indicated by a body mass index (BMI) of 30 or higher, has become a major health concern. In 2014, 21.5% of the men and 24.5% of the women in Europe, and 21.9% of men and 18.5% of women in Germany were classified as obese. In the US, it was as much as about one third of the adult population (WHO, 2015). These numbers are alarming, because obesity increases the risk of numerous diseases (Guh et al., 2009). It is also linked to psychological problems, such as stigmatization (Warschburger, 2011) and low self-esteem (Strauss, 2000). At the societal level, obesity leads to substantial financial expenses (Powers, Rehrig, & Jones, 2007). Consequently, studying treatments for obesity is an important task in clinical research.

Why do individuals with obesity engage in unhealthy food consumption (e.g., binging on chocolate) that causes substantial psychological discomfort (e.g., bad conscience) and clearly adverse health consequences in the long run? Even if aware of the consequences, individuals with obesity show substantial problems controlling the intake of freely available food (Trinko, Sears, Guarnieri, & DiLeone, 2007). This repeated, often uncontrollable or excessive intake of food promises short-term reward at the expense of long-term well-being and seems to parallel addictive behavior. Research indeed supports the notion that obesity and addiction share key behavioral and neurological similarities.

Berridge (2009) argued that the paradox of unhealthy consumption, in addiction and obesity alike, can be explained by two related, but dissociable processes: "liking" and "wanting". Liking is an affective state based on the hedonic enjoyment of food (Stahl, Unkelbach, & Corneille, 2009) and plays an important role in initiating a reinforcing value. "Wanting" can be referred to as craving of a certain rewarding stimulus, independent of liking the stimulus. Wanting is the central mechanism for the initiation of behavior to obtain rewarding stimuli. This idea originally stems from the incentive sensitization theory of addiction (Berridge, 2009; Berthoud, 2007), but has also been applied

* Corresponding author. Behavioural Science Institute, Radboud University Nijmegen, PO Box 9104, 6500 HE Nijmegen, The Netherlands.
E-mail address: m.rinck@psych.ru.nl (M. Rinck).

[1] Hannah Ferentzi and Hannah Scheibner contributed equally to this publication.

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to obesity. The theory describes the idea that stimuli become incentives by repeated exposure, based on conditioning processes. This leads to an abnormally strengthened association between cues (in the case of obesity, palatable food) and their positive motivational value. At the behavioral level, this results in repeated, often uncontrollable and excessive intake of food (Berridge, 2009).

The automatic and cue-driven nature of this incentive sensitization process has also been shown for eating behavior. For example, Veenstra and de Jong (2010) demonstrated that restrained eaters show increased automatic approach tendencies towards food. Similarly, Havermans, Giesen, Houben, and Jansen (2011) found that men with obesity have a pronounced approach tendency towards high-caloric food. Stice, Lawrence, Kemps, and Veling (2016) recently concluded that interventions which target the automatic approach response to high-caloric food cues might be an effective means to achieve long-term weight loss. To counteract automatic approach reactions in unhealthy consumption behavior, researchers have used the approach-avoidance task (AAT) developed by Rinck and Becker (2007). In the original assessment AAT, participants pull and push a joystick in response to positive and negative cues, while their reaction times are registered. In the training version of the task, also called approach bias modification, participants learn to repeatedly push pictures of addiction cues away while pulling control pictures towards themselves. The goal of this training is to weaken automatic approach tendencies towards addiction cues, and it should ultimately lead to reduced approach of addictive stimuli in real life.

Approach bias modification has been adapted to unhealthy food consumption in recent years, and the results are promising. A recent review concludes that approach bias modification is effective at retraining approach biases for several appetitive cues (in particular, alcohol and unhealthy food consumption) and that successful reduction of approach bias generally also changes unhealthy consumption behavior subsequently (Kakoschke, Kemps, & Tiggemann, 2017).

However, whether successful approach bias modification also influences eating behavior is still subject of scientific controversy, as there are mixed results. For instance, Schumacher, Kemps, and Tiggemann (2016) found that a chocolate-approach-avoidance training influenced approach tendencies and eating behavior in a subsequent taste test, whereas Becker, Jostmann, Wiers, and Holland (2015) found neither a significant change of approach-avoidance bias nor an effect on eating behavior. Stice et al. (2016) speculate that the mixed results observed so far might be explained by the nature of the control condition. While Schumacher et al. (2016) used a control condition in which participants were trained to approach high-caloric foods, Becker et al. (2015) used a sham training control condition without contingency.

Importantly, most studies that investigated the approach bias modification as a means to change unhealthy eating behavior were conducted with university students unselected for body weight, and they assessed only short-term effects of the trainings (Becker et al., 2015; Fishbach & Shah, 2006; Kemps, Tiggemann, Martin, & Elliott, 2013; Schumacher et al., 2016). This is unfortunate because the ultimate goal of these trainings is their application in individuals suffering from obesity, to achieve long-term changes in eating behavior and long-term weight reductions.

Therefore, we conducted a study in which we selected participants according to their body mass index (BMI; ≥ 30) at a German inpatient clinic for psychosomatic disorders. Moreover, we used a control condition in which participants received a sham training without contingencies. We developed a food-specific approach bias modification training which followed the principles of a successful alcohol-specific approach bias modification developed by Wiers and colleagues (Eberl et al., 2013; Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011; Wiers, Rinck, Kordts, Houben, & Strack, 2010). Instead of focusing on a specific type of food (e.g., chocolate), we used pictures that represented diverse categories of unhealthy, high-caloric food (e.g., hamburgers, French fries, chocolate, cake), in order to enhance ecological validity of the training. Diverse categories of positive non-food pictures (e.g., cute animals, landscapes, leisure activities in nature, social interactions) were used as to-be-approached stimuli of the training. Unlike other studies, we did not employ "healthy food" pictures as the to-be-approached stimulus category because this would not have been in line with the purpose of the nutrition advice program to which the training was an add-on. Positive pictures rather than neutral pictures were used because other studies had shown a generally beneficial effect of an approach-positive training (Becker et al., 2016).

Based on the above-mentioned findings of automatized behavioral tendencies towards food in obesity and recent studies demonstrating successful modification of the bias, we hypothesized that the bias of patients with obesity can be re-trained. Specifically, our first primary outcome variable was response speed in the AAT: We expected faster avoidance and slower approach of trained food stimuli as a result of the training. According to MacLeod, Koster, and Fox (2009), when conducting bias modification research, it is crucial to confirm that the effects generalize to new stimuli, as well as to new measures of the targeted cognitive process. Therefore, we hypothesized that the training would generalize to new, untrained pictures. Accordingly, our second primary outcome variable was AAT response speed for pictures not used in the training. For these new food pictures, we also expected the training to cause faster avoidance and slower approach.

Moreover, in a study that applied a very similar training in alcohol-addicted inpatients (Wiers et al., 2011), a transfer effect of the pictorial approach-avoidance training to implicit approach-avoidance associations for new, verbal stimuli was found. Therefore, as a secondary outcome, we also tested for such a transfer effect, using a Single Target Implicit Association Test of approach-avoidance associations for words (STI-IAT; Karpinski & Steinman, 2006). Finally, based on findings that approach bias modification potentially yields behavior change (e.g., Schumacher et al., 2016), we tested whether the training would affect variables related to eating behavior. Therefore, additional secondary outcome variables were changes in weight and in self-reported eating pathology during the stay at the clinic.

To sum up, half of the participants in our experiment were trained to push away high-caloric food pictures and pull positive pictures closer; the other half pushed and pulled both picture types equally often. As primary outcome, we hypothesized that the training would change the bias for the trained pictures as well as for new pictures. As secondary outcomes, we tested whether the bias change would generalize to approach-avoidance associations for words tested with a ST-IAT, and whether the training would affect weight loss and eating pathology.

2. Methods

2.1. Participants and design

Participants were 189 patients with obesity (BMI ≥ 30) of the salus clinic in Lindow, Germany. A BMI of less than 30 and a primary diagnosis of alcohol dependence were the only exclusion criteria. The training was an add-on to the standard nutrition advice program of the clinic, which is given in addition to the treatment of the patients' primary disorder. Of the participants, 15 dropped out of the training or were discharged from the clinic before completion of the training, another 14 participants had to be excluded due to technical difficulties, and another 31 participants were excluded because they made more than 40% errors on one of the two assessment AATs. The remaining 129 participants (63 female and 66 male) were on average 48 years old (SD = 9.45, range 22–64) and had an average BMI of 34.4 (SD = 4.25, range 29.5–51.3). All analyses reported below are based on this sample of 129 training completers because our primary outcome variables required complete AAT data.

The patients were in treatment for psychosomatic disorders; their primary diagnoses were major depression (n = 68), adjustment disorder (n = 9), dysthymia (n = 2), somatoform disorder (n = 7), generalized anxiety disorder (n = 2), specific phobia (n = 9), panic disorder (n = 6), post-traumatic stress disorder (n = 2), obesity (n = 4), personality disorders (n = 3), and pathological gambling (n = 17). The patients stayed in the clinic for an average of 38 days (M = 37.7, SD = 12.8).

Each participant was pseudo-randomly assigned to the active training group (n = 64) or the sham training control group (n = 65) in alternating order of appearance. Patients were blinded to the difference between active vs. sham training by receiving plausible training rationales for both versions, and by being led to believe that they received a training tailored to their individual needs. The current sample size yields very good power of 1-ß = 0.98 for the detection of medium-sized 2 × 2 interactions (with f = 0.25, p = .05, and a repeated-measures correlation of only r = 0.10), and good power of 1-ß = 0.88 for the detection of medium-sized between-group differences after training (with f = 0.25, p = .05). The groups did not differ significantly by age, sex, or type of diagnosis, $t(127) = 0.46$, p = .647, $chi^2(1, N = 129) = 0.63$, p = .427, $chi^2(10, N = 129) = 12.04$, p = .282, respectively.

2.2. Procedure overview

The study took place at a German rehabilitation clinic. All patients had access to the clinic's dining hall where a food buffet was offered to them for breakfast, lunch, and dinner. They were free to choose the amount of food consumed, and they could buy additional food items (mostly snacks and sweets) in a snack shop located in the clinic. Upon arrival at the rehabilitation clinic, patients' BMI was assessed and all patients' with a BMI > 30 were invited to participate in the study. At intake, participants filled out the Three-Factor Eating Questionnaire (Stunkard & Messick, 1985). Approximately two weeks after intake, participants performed the approach-avoidance assessment and training, which took place on four consecutive days, for 15–30 min each. To keep satiation fairly constant, all training sessions were scheduled approximately 1 h after lunch.

On the first day of participation, participants were informed about the nature of the training, which was offered to all overweight patients as part of a “nutrition advice program”. They first filled in the State version of the Food Cravings Questionnaire (FCQ; Meule, Lutz, Vögele, & Kübler, 2012) with paper and pencil. Then, on the computer, participants performed a ST-IAT followed by a long assessment-AAT. Unbeknown to the participants, the long assessment-AAT could change into a training-AAT of 200 trials (in the active training condition), followed by a short assessment-AAT and a booster training of 40 trials. The latter was added to ensure that the assessment-AAT did not reduce the training effects. On the second and third day, participants performed a short assessment-AAT followed by the training-AAT. Again, the change from assessment-AAT to training-AAT happened without explanation. On the fourth day, participants performed a short assessment-AAT followed by the training-AAT and the long assessment-AAT, followed by a booster training of 80 trials. Then participants performed a second ST-IAT. Finally, they filled out the FCQ on paper and pencil. At outtake, participants' weight was measured, and the Three-Factor Eating Questionnaire was administered again. All patients gave their written informed consent.

2.3. Approach-avoidance task (AAT)

A food-specific AAT was developed, which consisted of 40 different pictures displaying high-caloric sweet and hearty food (e.g., pizza, chocolate, ice cream) and 40 different pictures displaying positive situations representing a healthy lifestyle (e.g., positive social interactions, activities in nature). Each of the AAT pictures existed in a slightly left-tilted and a slightly right-tilted version, as well as in seven different sizes. The different sizes were created from each picture in order to program the zooming effect of the task, with the smallest picture measuring 75 × 58 pixels, and the largest picture measuring 976 × 768 pixels, with a resolution of 72 pixels per inch.

A joystick was fixed on the table, in front of the computer screen. The participant was seated in front of the computer and had to hold the joystick in the central position. By pushing the fire button of the joystick with the index finger, the first trial was initiated and a picture of medium size appeared on the computer screen. The participant was asked to react as quickly as possible to the tilt of the picture. If the picture was tilted left, participants had to push the joystick away, if the picture was tilted right, they had to pull the joystick closer. For practical reasons, all participants received the same instructions because in earlier studies, the assignment of the task-relevant feature (here tilt) to movements (pull vs. push) had never had any effect on responses. The joystick movement led to an increase (pull) or decrease (push) in size of the picture. Back-and-forth movements of the joystick were accompanied by corresponding dynamic changes in picture size. If the participant moved the joystick completely in the correct direction, the picture disappeared. The joystick then had to be moved back to the central position, and the next trial started when the participant pushed the fire button again. The computer recorded participants’ reaction time per trial, from the appearance of each picture to its disappearance.

2.3.1. Training-AAT

For the training-AAT, 20 of the 40 food-related pictures, and 20 of the 40 positive pictures were randomly selected. The selection of 20 out of 40 pictures in the training-AAT allowed for the test of a generalization effect in the assessment-AAT (see below). Participants who received the active training-AAT had to push all food-related pictures and pull all positive pictures. Participants receiving the sham training-AAT had to push 50% of the food-related pictures and 50% of the positive pictures, while they had to pull the other 50%, respectively. Therefore, no contingency was provided in this sham training. Per training session, each of the 20 different pictures per category (food, positive) was presented five times; leading to a training-AAT of 200 trials, with two short breaks in between.

2.3.2. Assessment-AATs

Two different assessment-AATs were programmed: a short version for the assessment of changes between training sessions, and a long version for the assessment of the overall training effect. The short assessment-AAT comprised 10 of the 20 trained food-related pictures, and 10 of the 20 trained positive pictures. Each picture was presented twice (once tilted left, once tilted right) and thus had to be pushed once and pulled once, leading to an assessment phase of 40 trials.

The long assessment-AAT contained 40 pictures (20 food-related and 20 positive), with each picture being presented twice (one tilted left, once tilted right), leading to an assessment phase of 80 trials. Half of the food pictures and half of the positive pictures used in this AAT were also used for training in the training-AAT, while the other half were not used during training. These 10 untrained food pictures and 10 untrained positive pictures enabled us to test for generalization effects to untrained items of the same category. The long assessment-AAT was administered before the first training-AAT on day 1, and after the last training-AAT on day 4. It was used to assess the predicted training effect. The short assessment-AAT was used at the end of day 1, and at the beginning of days 2, 3 and 4. Each training session started practice trials, namely 8 practice trials on day 1, and two practice trials on all other days.

2.4. Secondary outcome measures

2.4.1. Single target IAT (ST-IAT)

The ST-IAT (Karpinski & Steinman, 2006) is a variation of the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998).

The ST-IAT measures implicit associations between a single target category (in this case, 10 food-related words) and two attribute categories (in this case, 5 words related to approach and 5 words related to avoidance). Examples of approach and avoidance words are touch or take (approach) versus remove or push (avoidance). Examples of food-related words are chocolate, pizza, or burger.

The participant was seated in front of the computer. In the middle of the computer screen, words appeared one by one. Participants had to assign each of the presented words to one of the three reference categories ("food", "approach", "avoidance"), which were displayed on the upper right or upper left part of the screen throughout each block. The participant was instructed to react to the words as quickly as possible, assigning them to the most appropriate reference category by pressing one of two keyboard keys ("A" for the left category or "L" for the right category). The category labels were presented as a reminder in the top right and top left corner of the computer screen throughout each block. After the response, the word disappeared, and the next word was presented. Incorrect responses were signaled with the word "error", with the next trial following.

The task consisted of five blocks: First, in the "attribute practice block", the participant had to categorize approach words and avoidance words into the appropriate categories "approach" (left key A) or "avoidance" (right key L). This block consisted of 20 trials (each of the approach and avoidance words was presented twice), in random sequence. Second, a "first target practice block" followed, where 10 food words were presented on the screen that all had to be assigned to the "food" category by pressing the right key L. Third, a combined "food-avoidance block" followed (75 trials), where the participant had to categorize all words into all three categories, "approach" (30 trials), "food" (30 trials), and "avoidance" (15 trials), by pressing the left key for approach words and the right key for avoidance words and food words. This combined block is referred to as the "compatible block" because the pairing of food and avoidance is compatible with the training-AAT. Fourth, a "second target practice block" followed, where the 10 food words were presented again. As before, they all had to be assigned to the "food" category, but this time by pressing the left response key A, shown in the upper left corner of the screen. Fifth, a combined "food-approach block" followed (75 trials). Mirroring the food-avoidance block, this time the participant had to categorize words into all three categories, "avoid" (30 trials), "food" (30 trials), and "approach" (15 trials), by pressing the left key for approach words and food words, and the right key for avoidance words. This combined block is referred to as the "incompatible block" because it is incompatible with the training-AAT. For the analysis, only latencies in the combined blocks were used. The first 10 trials each of the incompatible and compatible block were excluded as practice trials.

2.4.2. Body mass index (BMI)

BMI was the primary clinical outcome measure of this study, which was assessed by measuring height and weight of each patient at the day of the intake and at discharge from the clinic.

2.4.3. Eating psychopathology

The German version (Fragebogen zum Essverhalten, FEV, Pudel & Westenhöfer, 1989) of the Three-Factor Eating Questionnaire (TFEQ, Stunkard & Messick, 1985) was used to measure eating psychopathology. The questionnaire assesses cognitive control (21 items), disinhibition (16 items), and hunger (14 items). These subscales have good internal consistency (all Cronbach's alpha > .85), and good validity, e.g. by predicting obesogenic eating style (Bryant, King, & Blundell, 2008).

2.4.4. State craving

State craving was assessed with the state version of the German Food Cravings Questionnaire (FCQ; Meule et al., 2012). The questionnaire has a very good internal consistency (Cronbach's alpha = .95), and sufficient construct validity (e.g., correlation with time elapsed since the last meal ($r = 0.25$).

3. Results

3.1. Data preparation

For the analysis of the AAT and ST-IAT, we used the scoring algorithm developed by Greenwald, Nosek, and Banaji (2003). This algorithm standardizes the difference in response latencies by dividing an individual's difference in response times by a personalized standard deviation of these response latencies. We present these standardized *D* scores for both the AAT and the ST-IAT as primary outcome variables. The interpretation of the D scores is as follows: Higher D scores for unhealthy food pictures in the AAT indicate more approach and less avoidance of unhealthy food. Accordingly, in the ST-IAT, higher D scores indicate a stronger association between unhealthy food and approach than between unhealthy food and avoidance. Thus, the present training aimed to reduce these D scores, and possibly turn them into negative scores which would indicate avoidance of unhealthy food.

3.2. Primary outcome: effects of the AAT training on the Assessment-AATs

We performed a 2 (time: pretest, posttest) × 2 (picture type: food, positive) × 2 (stimuli: trained, untrained) × 2 (training group: active, sham) mixed-factors ANOVA, with D scores of the assessment-AATs as the dependent variable. The analysis revealed a main effect of picture type, $F(1,127) = 16.62$, $p < .001$, $\eta_p^2 = 0.12$, suggesting that on average, participants showed more avoidance of unhealthy food pictures ($M = -0.12$, $SE = 0.03$) than of positive pictures ($M = -0.01$, $SE = 0.03$). There was no main effect of time, $F(1,127) = 0.85$, $p = .36$, $\eta_p^2 = 0.007$, but a significant interaction of picture type and time, $F(1,127) = 42.87$, $p < .001$, $\eta_p^2 = 0.25$. Participants developed more approach of positive pictures ($M = -0.11$, $SE = 0.04$ at pretest vs. $M = 0.09$, $SE = 0.04$ at posttest) and more avoidance of unhealthy food pictures ($M = -0.05$, $SE = 0.03$ at pretest vs. $M = -0.18$, $SE = 0.03$ at posttest). Most importantly, the three-way interaction of training, time, and picture type was also significant, $F(1,127) = 4.94$, $p = .028$, $\eta_p^2 = 0.04$). Inspection of the means shown in Table 1 reveals the nature of this interaction: Before training, the two groups did not differ in their response to positive pictures, $t(127) = 1.15$, $p = .25$, or food pictures, $t(127) = 0.29$, $p = .77$. After training, participants in the active training group had developed more approach of positive pictures than the control group, $t(127) = 2.22$, $p = .03$, and more avoidance of unhealthy food pictures, $t(127) = 1.98$, $p = .05$. Regarding changes in response tendencies, both trainings led to more approach of positive pictures (active: $t(63) = 3.70$, $p < .001$; sham: $t(64) = 2.45$, $p = .02$), whereas only active training led to more avoidance of food pictures (active: $t(63) = 3.91$, $p < .001$; sham: $t(64) = 0.95$, $p = .35$). Finally, the four-way interaction of training, time, picture type, and stimuli was not significant, $F(1,127) = 0.74$, $p = .39$, $\eta_p^2 = 0.006$, suggesting that

Table 1
Mean D scores on measurement AATs (with SDs) at pretest and posttest.

	Active Training	Sham Training
Pretest		
Food trained	−.07 (.46)	−.01 (.46)
Food untrained	−.02 (.39)	−.11 (.52)
Positive trained	−.02 (.52)	−.16 (.52)
Positive untrained	−.10 (.45)	−.13 (.53)
Posttest		
Food trained	−.22 (.51)	−.15 (.47)
Food untrained	−.28 (.47)	−.09 (.53)
Positive trained	.20 (.45)	−.06 (.54)
Positive untrained	.13 (.52)	.08 (.45)

the training effect was not larger for trained pictures than for untrained ones.

In sum, our hypothesis was confirmed: Participants did develop an approach bias regarding positive pictures and an avoidance bias regarding unhealthy food pictures, and this effect was stronger after active training than after sham training.

3.3. Primary outcome: generalization to untrained pictures in the AAT

To test whether the observed training effect indeed generalized to untrained pictures, we conducted an additional analysis of the D scores of untrained pictures only. This resulted in a 2 (time: pretest, posttest) × 2 (picture type: food, positive) × 2 (training group: active, sham) mixed-factors ANOVA (see Table 1 for means and SDs). The results paralleled those of the overall analysis just described. Most importantly, the critical interaction of picture type, time, and training group was significant as well, $F(1,127) = 4.88$, $p = .029$, $\eta_p^2 = 0.04$. The nature of the interaction was similar, too: The two training groups did not differ in how much approach of positive pictures they developed (+23 vs. +21, $F(1,127) = 0.04$, $p = .84$, $\eta_p^2 < 0.001$). However, as intended by the training, participants in the active training group developed more avoidance of unhealthy food pictures than participants in the control group (−26 vs. +2, $F(1,127) = 7.06$, $p = .009$, $\eta_p^2 = 0.05$). In sum, our hypothesis was confirmed, even for pictures that the participants had not been trained with.

3.4. Secondary outcome: effects of the AAT training on the ST-IAT

As a second step, we investigated whether the AAT Training affected approach-avoidance associations with unhealthy food words, as measured with the ST-IAT. We performed a 2 (time: pretest, posttest) × 2 (training: active, sham) mixed-factors ANOVA with ST-IAT D scores as the dependent variable (after excluding practice trials). We found a significant main effect of time, $F(1,121) = 23.1$, $p < .0005$, $\eta_p^2 = .17$: After the training, participants showed stronger avoidance associations with unhealthy food words than before the training (see Table 2). However, there was no significant interaction time and training group, $F(1,121) = 0.32$, $p = .57$. In contrast to our hypothesis, after active training participants did not develop stronger avoidance associations with unhealthy food words than after sham training.

3.5. Secondary outcome: effect of the AAT training on BMI

Next, we investigated whether the AAT training affected BMI. For this purpose, we performed a 2 (time: pre, post) x 2 (training: active, sham) mixed-factors ANCOVA, with number of days between weight measures as a covariate and BMI as the dependent variable (for means and SDs, see Table 2). The main effect of time was marginally significant, $F(1,121) = 2.79$, $p = .10$, $\eta_p^2 = 0.23$. On average, participants had a slightly lower BMI at the end of their stay at the clinic ($M = 34.0$, $SE = 0.37$) than at arrival ($M = 34.5$, $SE = 0.38$). In addition, there was a main effect of training group, ($F(1,121) = 5.40$, $p = .024$, $\eta_p^2 = .04$: Participants in the control group were on average slightly heavier ($M = 35.1$, $SE = 0.53$) than those in the active training group ($M = 33.4$, $SE = 0.53$). Most importantly, however, we did not find the expected interaction of time and training group, $F(1,121) = 0.58$, $p = .447$, suggesting that the active training did not reduce BMI more than the sham training did. Moreover, exploratory moderator analyses did not reveal a significant moderator of the effect of training on BMI.

Table 2
Mean ST-IAT D scores, BMI values, TFEQ scores, and FCQ scores (with SDs) at Pretest and Posttest.

	Active Training	Sham Training	p of *t*-Test
ST-IAT Pretest	.12 (.26)	.11 (.24)	$t(121) = .24$, p = .81
ST-IAT Posttest	.01 (.25)	−.03 (.21)	$t(121) = .97$, p = .332
BMI Pretest	33.58 (3.98)	35.18 (4.39)	$t(127) = 2.163$, $p = .032$
BMI Posttest	33.12 (4.05)	34.81 (4.07)	$t(123) = 2.336$, $p = .021$
TFEQ Pretest	6.26 (2.39)	5.74 (2.38)	$t(122) = 1.217$, $p = .226$
TFEQ Posttest	5.12 (1.84)	5.11 (2.35)	$t(106.1) = .074$, $p = .941$
FCQ Pretest	1.75 (2.44)	1.34 (2.13)	$t(126) = 1$, $p = .317$
FCQ Posttest	.81 (1.95)	.34 (1.06)	$t(97.1) = 1.69$, $p = .093$

Note: ST-IAT = Single Target Implicit Association Test, BMI = Body Mass Index, TFEQ: Three Factor Eating Questionnaire.

3.6. Secondary outcome: effect of the AAT training on self-reported eating pathology

3.6.1. TFEQ

For each of the three TFEQ subscales (hunger, cognitive control, disinhibition), we performed a 2 (time: pre, post) x 2 (training: active, sham) mixed-factor ANOVA. For the hunger and disinhibition subscales, we found a significant main effect of time, $F(1,108) = 41.43$, $p < .0005$, $\eta_p^2 = 0.28$ and $F(1,109) = 24.15$, $p < .0005$, $\eta_p^2 = 0.18$, respectively. On average, participants were less hungry after the training ($M = 4.65$, $SE = 0.33$ before training vs. $M = 2.67$, $SE = 0.26$ after training), and felt less disinhibited ($M = 6.78$, $SE = 0.29$ before training vs. $M = 5.31$, $SE = 0.24$ after training). Most importantly, there was no significant interaction of time and training for any of the three subscales, $F(1,109) = 1.90$, $p = .171$; $F(1,109) = 0$, $p = .986$; and $F(1,109) = 0.04$, $p = .85$).

3.6.2. FCQ

The 2 (time: pre, post) x 2 (training: active, sham) mixed-factors ANOVA of the FCQ scores revealed neither a significant main effect of time, $F(1,126) = 1.27$, $p = .26$) nor a significant interaction of time and training, $F(1,126) = 1.01$, $p = .317$).

4. Discussion

The goal of this study was to evaluate a food-specific approach-avoidance training in inpatients with obesity. In the active training condition, patients were trained to avoid pictures of palatable unhealthy food, and to approach positively valenced pictures. In contrast, patients in the sham training control condition approached and avoided both types of pictures.

The active training successfully changed initial approach-avoidance tendencies, more than the sham training did. Particularly, the 4-session training facilitated faster avoidance movements away from unhealthy food pictures and faster approach movements towards positive pictures, more so than the sham training did. This is a promising result because we used a control group that received a sham training without contingency. A larger difference could be expected when the active food-avoidance training with 100% food-avoidance were compared to a training with a reversed contingency, that is, a 100% food-approach training. However, use of the latter training is hard to defend for ethical reasons when conducting research with patients, therefore we did not consider it. Stice et al. (2016) attributed mixed results in past studies to the nature of the control groups. In this light, our results add to current research by pointing to the efficacy of the training, even when it is being compared to a sham training control condition.

As expected, the training generalized to new, untrained pictures, which shows that the effect is not isolated and limited to the trained stimulus materials. Instead, the training effect seems to translate to a conceptual level of processing. However, contrary to our expectations, the training effect did not generalize to the ST-IAT. The transfer from a picture-based AAT that measures and manipulates approach-avoidance action tendencies, to a word-based ST-IAT that measures approach-avoidance associations is relatively far, as both the type of bias (from movements to associations) and the stimuli (from pictures to words) change. This might explain the lack of a transfer effect, but see Wiers et al. (2011) where this effect was observed. The fact that food-associations became generally more negative, independently of the training, may be explained by the nutrition advice in the clinic.

Furthermore, the training did not affect weight loss during the stay in the clinic. This could mean that the training was not effective in changing eating behavior and, subsequently, weight loss. However, it needs to be kept in mind that weight loss was not the primary goal of our participants, and that all but four of them were in treatment for a range of other disorders. Since individual motivation to change may play a crucial role in the effectiveness of the training, asking patients to participate in a nutrition advice program and a four-session food-avoidance training on top of their main treatment may have taxed their motivation too much. Lack of motivation is also a likely explanation for the unusually high number of participants who produced high error rates in a task as simple as the AAT. Indeed, previous successful applications of approach-avoidance trainings have usually addressed the primary problem of patients who were motivated to change (Eberl et al., 2013; Wiers et al., 2011). Hardly ever did a training address a comorbid problem, e.g., smoking in psychiatric inpatients (Machulska, Zlomuzica, Rinck, Assion, & Margraf, 2016). Moreover, the training did not affect the patients' responses in questionnaires on eating pathology. While eating pathology questionnaires generally predict food intake, they do not directly measure eating behavior. Whether a transfer of approach-avoidance bias modification to concepts like disinhibition and craving can be expected should be investigated in future studies. Also, direct observations of eating behavior and behavioral assessments should be included (food diaries, taste tests etc.), and true randomization rather than pseudo-randomization should be used to assign patients to training conditions.

As the training did not significantly change our secondary outcome measures, we have to conclude that the training effect was isolated. An explanation for this may be the complex nature of eating behavior. A multitude of factors, homeostatic and non-homeostatic, influence food intake and subsequently, weight gain. These factors might stabilize each other to the degree of a behavioral equilibrium that cannot easily be perpetrated by targeting a single factor. It is important to note, however, that at the end of their stay in the clinic, participants had lost weight, were less hungry and reported less inhibition (as measured with the TFEQ). Also, participants showed a less pronounced implicit association bias towards food after the training. All those effects were independent of the specific training group, however. Thus, the most plausible and parsimonious explanation may be that the standard nutrition advice program of the clinic was effective. It cannot be decided whether both the active training and the sham training had an additional effect, or whether none of them was effective. Moreover, to clearly demonstrate beneficial effects of any training on clinical variables including weight, intention-to-treat analyses need to be computed in addition to the completer analyses reported here.

Our results add insights into several important aspects. First, this study employed a food-specific approach bias modification that comprised diverse palatable food stimuli. This is important in the light of the ecological validity of the training. Second, as we used a sham training control group, we can infer that our active training did indeed modify the bias. Third, to our knowledge this is the first study to show that the training can be administered to inpatients of a psychosomatic clinic, which points towards the applicability of the training in clinical groups. Fourth, our results show that the training effect generalized to new pictures in the same task, but not to words in a different task, the ST-IAT. Moreover, we did not observe any effect of the training on the clinical outcome variables, which clearly calls the clinical value of the training into question. This null result is in contrast with results of earlier studies which did find effects on behavioral outcome variables. Those studies differ from ours in several ways, however, and none of them involved weight reduction in inpatients with obesity. Therefore, follow-up studies will be crucial. Whether approach modification training in clinical populations can change the bias in the desired direction *and* translate to less food intake has yet to be determined.

For future research, it will be important to study whether clinical training effects can be induced by tailoring the training materials to individual eating habits and personal food preferences. Furthermore, it would be important to investigate the relationship between attentional (distraction) processes and implicit behavioral tendencies, in order to identify the underlying processes. For the latter, it would also be important to separate the effects (if there are any) of trained avoidance of unhealthy food stimuli versus trained approach of positive stimuli, similar to what Ferrari, Möbius, Becker, Spijker, and Rinck (2018) recently reported. Above that, there may be patient characteristics that influence the presence and magnitude of the bias (e.g., personality or motivational aspects). In order to be able to maximize efficiency of the training, it would also be useful to determine the optimal number of training sessions. The current choice of 4 sessions was determined by practical limitations, but we know from alcohol-avoidance trainings that patients differ greatly in the number of sessions needed, and that many of them need at least 6 sessions for optimal effects (see Eberl et al., 2014).

In sum, the current study showed that food-related approach-avoidance biases could be modified in a sample of psychosomatic inpatients with obesity. The training generalized to new pictures, but not to the ST-IAT, to weight loss, or to eating pathology questionnaires. If this is due to the complex nature of eating behavior or the result of methodological issues has yet to be explored. It would be especially interesting to measure weight development in the long run, and in highly motivated patients without comorbid diagnoses, to reduce interfering factors like low motivation. Because of the limitations of self-reports (eating pathology questionnaires), behavioral measures (e.g., taste tests, food choices) should be added. While our results are mixed, approach bias modification in obesity as an add-on to existing treatments is still a promising field of research. The current study suggests that food approach biases can be modified; now we have to find out how this modification can be translated into clinically meaningful changes in eating behavior.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.appet.2018.03.016.

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