A new approach to facilitating attentional disengagement from food cues in unsuccessful dieters: The bouncing image training task

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Abstract

This study tested the capacity of a modified Bouncing Image Training Task (BITT) to enhance unsuccessful dieters' attentional disengagement from food cues. Unsuccessful dieters were assigned to a training group performing daily BITT sessions for one week (*n* = 57) or a waitlist control group (*n* = 56). Change in attention was assessed using a visual search task and an odd-one-out task. Impact of the BITT on food craving and food intake were also assessed. Participants in the training group, compared to waitlist controls, showed reduced attention to food cues from pre- to post-training. Moreover, the reduction in AB to food cues exhibited by those who completed the BITT reflected the relative facilitation of attentional disengagement from food cues, rather than a reduction in attention engagement with food cues. The groups did not differ on food craving or intake post-training. It is concluded that the BITT is a promising procedure for directly manipulating individuals' attentional disengagement from food cues, though its capacity to enhance dieting success has not yet been established.

Keywords: Unsuccessful dieting; Obesity; Attentional bias; Attentional bias modification

Highlights

- BITT training reduced attention to food cues in unsuccessful dieters
- BITT training selectively altered attentional disengagement from food cues
- In current form BITT training did not change unsuccessful dieters’ eating behavior

A new approach to facilitating attentional disengagement from food cues in unsuccessful dieters: The bouncing image training task

The proportion of the population who are overweight or obese is at an all-time high, posing major societal problems (CBS, 2016; WHO, 2016). Being overweight or obese puts an individual at risk for several chronic diseases and psychological problems. For example, it is related to an increased risk for diabetes and hypertension, as well as depression and anxiety (Dixon, 2010; Luppino et al., 2010; Roberts & Hao, 2013). Although many overweight people try to lose weight by restricting their food intake (Wardle, Haase, & Steptoe, 2006), they often fail in their dieting attempts (e.g., Field et al., 2007; Knäuper, Cheema, Rabiau, & Borten, 2005). Such failures to restrict food intake, despite motivation to diet, might be partly due to the biased processing of food-related information. Heightened selective attention to food cues is suggested to be characteristic of people who are overweight or obese, and this attentional bias (AB) has been theoretically implicated in failure to restrict food intake. In the current study we examined whether a key aspect of AB to food cues can be decreased, in women who are motivated to diet, by using a new attentional bias modification (ABM) approach that we label the Bouncing Image Training Task (BITT; Notebaert et al., 2018). We also examined whether the BITT serves to decrease participants' food craving and food intake.

People commonly show an AB to cues that are motivationally salient (Pool, Brosch, Delplanque, & Sander, 2016). Accordingly, individuals with a healthy weight show an AB to food cues when they report hunger or are deprived of food but not when they are not hungry or have just eaten (Castellanos et al., 2009; Mogg, Bradley, Hyare, & Lee, 1998). Importantly, obese individuals show an AB to food cues even when they are satiated (Castellanos et al., 2009; Nijs, Franken, & Muris, 2010). Therefore, it has been suggested that a relatively strong AB to food inflates the likelihood of overeating and will set individuals at risk for becoming overweight and developing obesity (Berridge, 2009; Polivy, Herman, & Coelho, 2008).

Individuals with a relatively strong AB to food cues will experience greater cognitive exposure to food cues in the environment, which could increase craving for food. There is empirical evidence that AB to food cues is, indeed, associated with increased food craving (Kemps & Tiggemann, 2009; Smeets, Roefs, van Furth, & Jansen, 2008; Werthmann et al., 2011). Moreover, studies have found that individuals who are overweight, or obese, demonstrate relatively heightened AB to food cues (for a review, see Hendrikse et al., 2015), which has led to interest in the development of training procedures designed with the aim of reducing AB to food cues, in order to evaluate whether modification of this AB can enhance dieting success. However, there are also several studies that did not show such differences (see e.g., Field, Werthmann, & Franken, 2016 for a review), thereby casting some doubts on the robustness of the relationship between overweight/obesity and AB..

A number of studies have examined whether it is possible to modify individuals' attention to food (i.e., attentional bias modification; ABM) (Boutelle, Kuckertz, Carlson, & Amir, 2014; Boutelle, Monreal, Strong, & Amir, 2016; Kakoschke, Kemps, & Tiggemann, 2014; Kemps, Tiggemann, & Hollitt, 2014, 2016; Kemps, Tiggemann, & Stewart-Davis, 2018; Smith, Treffiletti, Bailey, & Moustafa, 2018; Verbeken et al., 2018). These studies have used adapted versions of visual probe tasks (MacLeod, Mathews, & Tata, 1986), configured with the aim of modifying AB to food cues. In the visual probe task, two images (or words) are shown simultaneously next to each other on the screen. After a short interval, a probe stimulus (e.g., a dot) appears in the location where one of the images was just shown, and the participant must quickly identify the location of this probe (e.g., Kemps et al., 2016). In variants of this task designed with the aim of reducing AB to food, the probes consistently appear in the location distal to the locus of stimuli. Thus, in visual probe tasks configured to reduce AB to food cues, each stimulus pair contains a food-related items and a non-food item, and the probe consistently appears in the location where the non-food item was just shown.

Several studies have shown that AB to food can be modified using this type of visual probe task. For example, obese individuals who performed such avoid-food training came to exhibit a decrease in AB to food, compared to those who received a variant of the task in which the probe consistently appeared behind the food item (Kemps et al., 2014). However, not all studies using this visual probe approach to ABM have been successful in changing AB to food cues (e.g., Boutelle et al., 2014; Verbeken et al., 2018). Also, several investigators report that participants find the visual probe ABM tasks boring and lacking in apparent purpose (e.g., Beard, Weisberg, & Primack, 2012; Brosan, Hoppitt, Shelfer, Sillence, & MacKintosh, 2011). More important still and of greatest relevance to the present research objective, the visual probe approach to ABM cannot differentially target the two distinct facets of AB (Grafton & MacLeod, 2014): attentional engagement with food cues, and attentional disengagement from food cues (Posner, 1980; Posner & Petersen, 1990). Especially the difficulty to draw attention away from food cues may contribute to an increased craving thereby lowering the threshold for actual food intake (cf., Franken, 2003). As such, reduced levels of attentional disengagement from food cues seems most directly implicated in compromising dieting success. The current study examined the capacity of a new ABM training task to specifically increase attentional disengagement from food cues in unsuccessful dieters.

In this study we evaluated a food variant of an ABM task, initially introduced by Notebaert et al. (2018) to modify AB to emotional stimuli. We term this approach the Bouncing Image Training Task (BITT). In the present BITT, eight square boxes simultaneously moved around a computer screen, bouncing off each other and the screen edges. Seven of these boxes contained images of food items (distractor boxes), and one contained an image of a non-food item (target box). Participants were instructed to attend only to the box containing the non-food item, and track this continuously by keeping the mouse cursor in the location of this moving box. At frequent intervals the images in the eight moving boxes changed. When, following such a change, the item shown in the moving box being tracked was another non-food item, this remained the target box, and the participant was required to sustain attention to this box and continue tracking it. However, when following such a change, the item shown in the moving box being tracked was now a food item, then the participant was required to immediately disengage attention from this stimulus. Another moving box now displayed the non-food item, thereby became the target box, and the participant was required to now track this new moving box for as long as the changing items displayed in this box remained non-food items. Thus, across the BITT session, each time the stimulus content of the moving box being tracked changed, the participant had to inhibit an attentional disengagement response if the box continued to display a non-food item, and had to immediately execute an attentional disengagement response if the box now displayed a food item. It was intended that exposure to the BITT would serve to train an attentional disengagement bias, reflecting heightened attentional disengagement from food cues relative to non-food cues.

Though we examined whether participants' performance on the BITT improved from pre- to post-training, such improvement need not reflect the acquisition of the intended change in AB (e.g., Heitmann et al., 2017). We therefore assessed the impact of the BITT training on two AB assessment tasks, the Visual Search Task (VST) designed to reveal general attentional bias to food cues (Hansen & Hansen, 1988), and the Odd One Out Task (OOOT) to differentially assess attentional engagement bias with food cues and attentional disengagement bias from food cues (Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005).

As a secondary issue, we tested the hypothesis that attentional bias to food cues, and perhaps specifically impaired attentional disengagement from food cues, causally contributes to food craving and food intake, by examining whether any change in such attentional bias experimentally elicited by the BITT impacted on food craving and food intake. There is some limited evidence that ABM designed to reduce attention to food cues can reduce food intake in the lab (Boutelle et al., 2014; Smith et al., 2018). However, because such lab tests might not accurately reflect real-life eating behavior, or elicit the craving experienced in naturalistic environments, the current study employed an interview approach to assess food consumption outside the laboratory.

In summary, the current experimental study tested the hypotheses that, when given to women who report dieting failure, this novel BITT approach: (1) will reduce general attentional bias to food cues; (2) will serve to specifically reduce attentional disengagement from food cues, rather than to reduce attentional engagement with food cues; and (3) may reduce food craving and consumption.

Method

Participants

Participants were 113 women between the ages of 17 and 35 (*M* = 20.99, *SD* = 3.21), who were currently trying to restrict their food intake with little success. Participants were selected via an online screening performed among first year Psychology students, and a call that was placed on Facebook with a link to the online screening (see Figure 1 for the flow chart). We screened using two questions adapted from the Eating Disorder Examination Questionnaire (EDE-Q) (Fairburn & Beglin, 2008): (1) ‘To what extent do you deliberately try to limit the amount of food you eat? (whether or not you succeed at this)’ (intention scale), and (2) ‘To what extent do you actually succeed to limit the amount of food you eat?’ (success scale). These questions were answered on a 7-point Likert scale, ranging from *not at all* (0)’ to *markedly* (6). Women marking a two or higher on the intention scale, and who were overweight, obese, or marked a three or lower on the success scale were invited to take part in the study. Individuals with a BMI below 21.75 were not included since it might negatively affect their health. Participants' BMI ranged from 21.76 to 41.61 (*M* = 25.55, *SD* = 3.72). Current sample size provides 84% power to find a medium effect size on the manipulation check and 88% power to find a small effect on the other attentional bias measures with the mixed model ANOVAs.

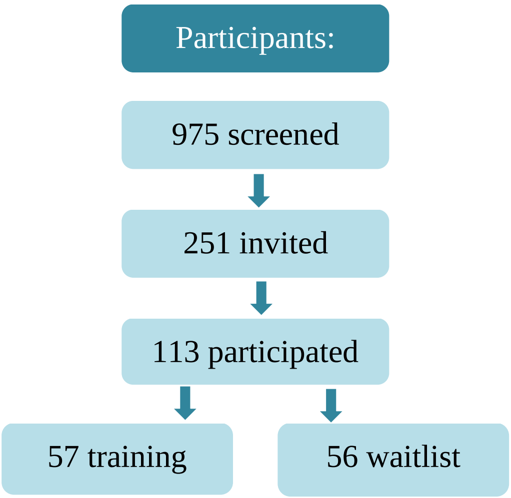

Figure 1 Flow chart of screening and group allocation.

Materials

Eating measures

Food deprivation

Because food deprivation could, potentially influence individuals' attention towards food cues, it was desirable that participants assigned to the alternative conditions did not differ in this regard. Therefore, food deprivation was assessed with the question; "How long has it been since you last ate?" from the Hunger Scale (Grand, 1968). Scores reflect the amount of hours that have passed since the participant last ate, rounded off to quarters of an hour.

Food craving

Food craving was measured using an adapted version of the short General Food Craving Questionnaire Trait (GFCQ-T) (Nijs, Franken, & Muris, 2007), measuring food craving over the preceding 24 hours. This questionnaire consists of 21 statements describing symptoms related to food craving (e.g., 'Once I started eating, I had trouble stopping'), and participants had to indicate the degree to which each statement applied to themselves yesterday, using a Likert scale ranging from *never or not applicable* (1) to *always* (6). Food craving is calculated by summing the response scores to these 21 items, with higher scores reflecting more food craving. Internal consistency of the questionnaire in the current study was excellent (Cronbach’s alpha of 0.95), and test-retest reliability assessed in the waitlist control group was good ($r = 0.84$, $p < 0.001$).

Food intake

To measure individuals’ food intake, a 24-hour dietary recall interview was conducted at the final assessment session by two dieticians in training. This food interview was only conducted once, as repeated measurement of consumption has been shown to influence respondents’ patterns of eating (Shim, Oh, & Kim, 2014). The food intake data was processed in Evry (version 1.4.6.3) which used the Dutch Nutrients File (i.e., NEVO, version 2016/5.0, RIVM, Bilthoven) to compute the amount of calories consumed by each participant across the final 24 hours of the study.

Attentional Task Stimuli

The attentional bias modification (BITT), and both AB assessment tasks (VST and OOOT) made use of the same stimulus images. There were three sets of stimulus images: one set comprised images of household items (66 images showing objects such as pushpins); one set comprised images of food items (66 images showing high caloric foods such as chocolate or hamburgers); and one set comprised flowers (30 images showing blooms such as roses). All but 12 of the images were selected from the food-pics database (Blechert, Meule, Busch, & Ohla, 2014), with the remainder drawn from our own database, and showing food items familiar to the Dutch population (e.g., croquette). All images were saved at a resolution of 273x273 pixels.

Attentional Tasks

Attentional bias modification training task (BITT)

The task employed with the aim of modifying AB to food cues was the Bouncing Image Training Task (BITT), designed by Notebaert, et al., (2018). In this task, eight square boxes moved continuously across the screen, bouncing off the screen edges and each other. Each box contained an image, and at any point in time all but one of the boxes displayed a food image, drawn from the stimulus set of food items. Participants were instructed to attend to the single box that contained a non-food image, and use the mouse to keep the cursor in the location of this target box (for a screenshot, see Figure 2). This non-food image was drawn from the stimulus set of household items. Once the cursor was in the correct position the image turned green for a 500 ms, indicating that the participant was tracking the correct image. At frequent intervals (see Table A for detailed information), the images in all boxes changed. Following any such change, the new image in the box previously being tracked by participants could either be another non-food image (e.g. with an interval between 1.82-3.82 s in level 3), in which case this remained the target box and the participant was required to continue attending to and tracking it. Alternatively, following such a change, the new image could be a food item (e.g., with an interval between 6.28 – 9.10 s in level 3), in which case the participant was required to disengage attention from it, and begin tracking the other box that now contained the single non-food item in the display.

Across the duration of the study, the BITT was delivered at increasing levels of difficulty (level 3 – level 12; cf., Heitmann et al., 2017) by increasing the speed of the box movement and the frequency with which their image content or category changed (see Table A). The aim of this was to ensure that the task remained challenging for participants. Each difficulty level was used for four blocks of the BITT, and each block took 2.5 minutes to complete. Therefore, each difficulty level was employed for 10 minutes. Participants could track how much of each block remained by viewing a countdown in the upper right corner of the screen. Every block employed a different random draw of images. To keep participants engaged and motivated, they earned points for keeping the mouse cursor in the location of the target box. Thus, the better they performed the task the more points they earned. These points were indicated with a green bar across the top of the screen, that progressively filled up as points accrued. At the end of each block, the total points earned was shown on the screen. Furthermore, participants were also shown their high score, and were told whether their most recent score was their highest score of the day.

Two outcome measures of the BITT are of interest in this study, the percentage of time, across each block, during which participants succeeded in keeping the mouse cursor in the location of the moving target (i.e., maintained attention), and the percentage of time that it takes an individual to find a new non-food image after the non-food item switches to a food item (i.e., switch duration).

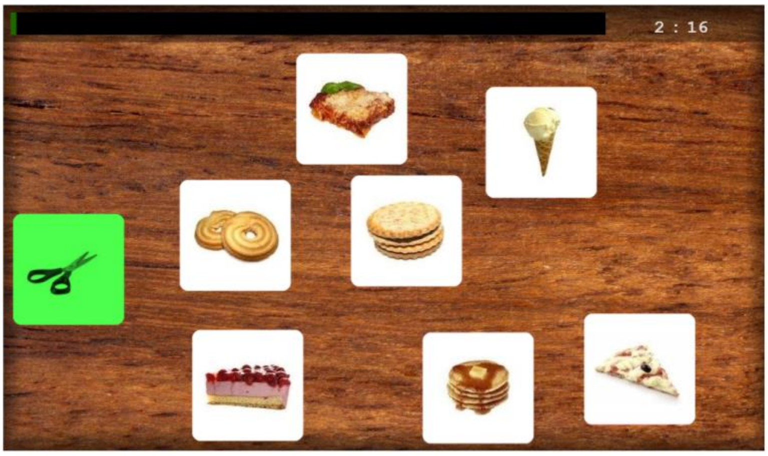

Figure 2 Screenshot of the BITT.

Task assessing general attentional bias to food cues (VST)

General attentional bias to food cues was measured using the Visual Search Task (Hansen & Hansen, 1988). During this task participants had to identify, as quickly as possible, the single image of a specified target category displayed within a matrix of images from a different category. On half the trials, this target was a food image displayed within a matrix of household object images. On the other half of the trials, this target was a household object image displayed within a matrix of food images. At the beginning of each trial a red cross appeared in the middle of the screen and participants had to move the mouse cursor over this cross to continue. Then a 4x4 matrix of images appeared and the participant was required to click on the target image as quickly as possible. The location of the target was random within the matrix. The visual search task comprised four blocks of 18 trials. Two of these blocks presented food targets displayed in matrices of non-food distractors, and the other two blocks presented non-food targets displayed in matrices of food distractors.

Data reduction. Participants whose accuracy fell more than 3 *SD*s below the mean accuracy level (Baseline < 96.50%; Post-training < 93.15%) were excluded (Baseline *n* = 2; Post-training *n* = 2). We also adopted the criteria of excluding trials on which participants responded faster than 200 ms (probable anticipations) or slower than 20000 ms (probable distractions), though this resulted in no data exclusion (Bongers et al., 2015). Finally, we excluded trials on which participants' response latencies fells more than 3 *SD*s above or below the mean response latency (Bongers et al., 2015; Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010). This eliminated 2.18% of the trials at Baseline and 2.07% of the trials at Post-training. An index of general attentional bias to food cues was then calculated, by subtracting the mean latency to correctly identify the food targets among the non-food distractors from the mean latency to correctly identify non-food targets among food distractors. Higher scores indicate greater general attentional bias to food cues.

Internal consistency of the VST was assessed by calculating attentional engagement and disengagement for the first and the second half of the task. The relationship between AB during the first half and the second half was moderate (Spearman-Brown = 0.48). Second, trials were assigned alternatingly to two different sets with the first trial being randomly assigned to the first or second set. The relationship between these two attentional bias measures was also moderate (Spearman-Brown = 0.46). Comparing the AB on pre and post-test in the waitlist control group showed a poor test-retest reliability ($r = 0.10$, $p = 0.507$).

Task assessing attentional engagement with and disengagement from food cues (OOOT). Biased attentional engagement with, and biased attentional disengagement from, food cues were separately assessed using the Odd-One-Out task (Rinck et al., 2005). In this task participants had to correctly indicate, as quickly as possible, whether or not one image in a 5 x 4 matrix belonged to a different category from that represented by the other 19 images. Participants were given a maximum of 10 seconds to respond using the keyboard, and they did so by pressing the 0 key (to indicate that there was no such “odd one out”) or by pressing the 1 key (to indicate that there was such an “odd one out”). This task used images from all three stimulus sets: food items, office items, and flowers.

At the beginning of each trial a red fixation cross appeared for 500 ms in the middle of the screen, then a 5 x 4 image matrix was presented. The odd-one-out image never appeared directly above or below the point where the fixation cross was shown. The task consisted of three blocks of 24 trials each. On 40% of trials, all the items in the array belonged to the same category (which was equally often food items, office items or flowers). However, the data of interest came from the remaining 60% of trials, on which one items was an odd one out. These critical trials were of the following three types, which occurred with equal frequency: i. *food item odd one out*, with distractors items all either office items or flowers; ii. *food items distractors*, with the odd one out being either an office item or a flower; iii. *no food items present*, and the odd one out was either an office item among flowers, or a flower among office items. Latencies to correctly respond on each such trials were recorded. The order of trial presentation was random.

Data reduction. Exclusion criteria were identical to those employed for the previous assessment task (VST). Thus participants whose accuracy fell more than 3 *SD*s below the mean accuracy (Baseline < 56.65%; Post-test < 56.78%) were excluded (Baseline *n* = 2; Post-test *n* = 2). Trials on which response latencies were either < 200 ms or > 20,000 ms, or fell more than 3SD from the mean response latency also were eliminated (Baseline = 0.60%; Post-test = 0.28%), as has been common in previous studies using this task (e.g., Bongers et al., 2015; Hollitt et al., 2010). As recommended by Rinck et al. (2005), the index of biased attentional engagement with food cues was calculated by subtracting the mean response latency on critical trials that appeared in the "*food item odd one out*" condition from the mean response latency on critical trials that appeared in the "*no food items present*" condition, Higher attentional engagement scores indicate greater attentional engagement with food cues. The index of biased attentional disengagement food cues was calculated by subtracting the mean response latency on critical trials that appeared in the *"no food items present"* condition from the mean response latency on critical trials that appeared in the *"food items distractors*" condition. Higher attentional disengagement scores indicate less attentional disengagement from food cues.

Internal consistency of each of these two measures, during baseline, was assessed in a similar manner to that employed for the general attentional bias index yielded by the VST. The relationship between the first half and the second half was good for attentional engagement (Spearman-Brown = 0.81) and for attentional disengagement (Spearman-Brown = 0.85). The relationship between the two attentional bias measures obtained via alternating assignment was poor for attentional engagement (Spearman-Brown = 0.09) and for attentional disengagement (Spearman-Brown = -0.14)[1]. Test-retest reliability was assessed in the waitlist

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[1] The difference between the first half/second half and alternating approach is expected to lie in the random trial order of the task. For the VST, which has a blocked design, the two approaches give approximately the same outcome. It seems that in the OOOT the trials influence each other and that therefore the order in which it was performed matters. By using the first half / second half approach this order effect is integrated, and a

control group by examining the relationship between attentional engagement and disengagement on pre and post-test. There was a moderate and statistically significant relationship found for attentional disengagement ($r = 0.46$, $p = 0.001$), whereas the correlation was small and not significant for attentional engagement ($r = 0.23$, $p = 0.112$).

Procedure

The study protocol was approved by the ethical committee of the psychology department of the University of Groningen (16050-SP). Participants completed the baseline session in the laboratory. In this session they first answered the food deprivation question, completed the VST, and completed the OOOT in a random order, before then completing the GFCTQ. They were then randomly assigned to either the BITT training or to the waitlist control condition. Those assigned to the waitlist control group were then sent home. Those assigned to the training group proceeded to complete the baseline BITT, which delivered trials at level 3 and level 12. After this they were instructed to complete the BITT every day and were told that this would take approximately 10 minutes a day (see Table 1 for the BITT levels assigned on these days). The researcher discussed with the participant how to best fit this into their daily schedule the upcoming week. For the next six days, participants in the training group received a daily email, with a link to the BITT they had to perform that day. Participants were permitted to catch up on a missed training by completing the BITT one day later than scheduled, and thus performing the BITT twice on that same day.

After one week, on the same day of week and time as the baseline session, participants returned to the lab for the post-training session. All participants first answered the food deprivation question, then completed the BITT one final time, delivered at level 3, level 12 and level 9, in that order. To prevent frustration before the post-test level 9 was added so as to

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good internal consistency is found. However, the alternating method potentially disturbs the order effect resulting in a low internal consistency.

not end with the most difficult and untrained level. From there on, participants in the two groups both completed the OOOT and the VST in the same order as baseline, followed by the GFCTQ. Lastly, the 24-hour dietary recall interview was conducted. Testing was only carried out on Tuesday-Friday, to ensure that the 24-hour period of consumption assessed by the interview did not include a weekend day.

Table 1. BITT level assignment

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Control	Baseline	-	-	-	-	-	-	Post-test
Training	Baseline BITT 3&12	BITT 6	BITT 7	BITT 8	BITT 9	BITT 10	BITT 11	BITT 3&12&9 Post-test

Note. Numbers following the BITT represent the BITT level.

Statistical analyses

BITT performance. To determine whether the training group improved in terms of BITT performance, paired samples *t*-tests were performed on scores obtained at baseline and at post-training, when performing this task at level 3 and level 12.

Effect of BITT on general attentional bias to food cues. To test whether the BITT had an effect on general attention bias to food cues, a 2x2 mixed model ANOVAs was performed on the bias index scores, yielded by the VST, with Group (Training vs. Waitlist Control) as a between subjects factor, and Assessment Point (Baseline vs. Post-training) as a within subjects factor.

Effect of BITT attentional engagement with and disengagement from food cues. To test whether the BITT served to specifically modify attentional disengagement from food cues, separate 2x2 mixed model ANOVAs were performed on the attentional engagement bias and attentional disengagement bias scores yielded by the OOOT, respectively indexing enhanced attentional engagement with food cues, and impaired attentional disengagement from food cues. Each ANOVA considered Group (Training vs. Waitlist Control) as a between subjects factor, and Assessment Point (Baseline vs. Post-training) as a within subjects factor.

Effect of BITT on craving. To test whether the BITT decreased craving, the general food craving scores were subjected to a 2x2 mixed model ANOVA, with Group (Training vs. Waitlist Control) as a between subjects factor, and Assessment Point (Baseline vs. Post-test) as a within subjects factor.

Effect of BITT on food intake. To test whether the BITT decreased food intake, the caloric intake of participants in the training and waitlist control groups, across the final 24 hours, was compared using an independent samples *t*-test.

Results

Descriptive statistics

There were no significant differences between the training and waitlist control groups with regard to age, BMI, and dieting intention or success (see Table 2). Although BMI of the training group did seem somewhat lower than that of the waitlist control group ($t(111) = 1.78$, $p = 0.08$).

Table 2.Group means on variables measured at screening

	Control group (*n* = 56)		**Training group (*n* = 57)**		**95% CI**	
	M	**SD**	**M**	**SD**	**Lower**	**Upper**
Age	21.14	3.07	20.84	3.36	-0.90	1.50
BMI	26.17	4.04	24.94	3.30	-0.14	2.60
Dieting intention	3.61	1.31	3.61	1.41	-0.51	0.50
Dieting success	2.16	1.41	2.05	1.25	-0.39	0.60

Likewise, there were no significant groups differences at baseline with regard to food deprivation (i.e., time since eaten), food craving in the preceding 24 hours, or in the measures of AB to food cues yielded by the visual search assessment task and the odd one out assessment task (see Table 3).

Table 3. Group means on variables measured at baseline

	Control group (*n* = 56)		**Training group (*n* = 57)**		**95% CI**	
	M	**SD**	**M**	**SD**	**Lower**	**Upper**
Food deprivation	2.33	4.64	1.50	2.84	-0.61	2.27
Food craving	66.68	20.71	68.29	21.20	-9.46	6.24
GAB Index	43.22	286.06	-42.30	302.66	-211.70	46.61
AEB Index	-235.04	419.52	-228.56	327.01	-151.37	138.41
ADB Index	368.62	419.87	369.56	428.17	-164.29	162.41

Note. Food deprivation = time since eaten in hours, food craving = total score on the food craving questionnaire, GAB Index = general attentional bias to food cues as measured by the visual search task, AEB Index = biased attentional engagement with food cues as measured by the odd one out task, ADB Index = biased attentional disengagement from food cues measured by the odd one out task.

Between the baseline and post-training assessment points, a total of 5 participants dropped out of the study: 2 from the 56 in the waitlist control group (4%), and 3 from the 57 in the training group (5%). Given that drop-out rate was low and comparable for both groups, analyses were performed on the completers. Of the completers in the training group 2 missed one training session, and the other 52 completed all training sessions.

BITT performance

Correlational analyses between BITT maintained attention and BITT switch duration showed that, although related, these two outcomes identify in part different behavior (level 3 $r = -0.33$, $p = 0.014$; level 12 $r = -0.39$, $p = 0.003$). Paired sample *t*-tests revealed that BITT performance significantly improved across the week, for both game levels (see Table 4).

Table 4. BITT performance on baseline and post-training

	Baseline (*n* = 54)		**Post-training (*n* = 54)**				**95% CI**		**Cohen's d**
	M	**SD**	**M**	**SD**	***T***	***p***	**Lower**	**Upper**	
Maintained attention level 3	71.05	14.92	81.94	13.36	-4.16	< 0.001	-16.15	-5.64	0.57
Maintained attention level 12	69.26	12.76	73.98	13.19	-2.63	0.011	-8.32	-1.11	0.36
Switch duration level 3	12.02	1.94	10.46	1.70	6.37	< 0.001	1.07	2.04	0.87
Switch duration level 12	19.58	2.86	18.35	3.04	3.02	0.004	0.41	2.05	0.41

Note. Maintained attention = the percentage of time during which the mouse cursor was in the location of the target, switch duration = percentage of time that it takes an individual to find a new non-food image after the non-food item switches to a food item.

Effect of BITT on general attentional bias to food cues

Mean general attentional bias scores obtained by participants in each group are shown in Table 5. A significant main effect of Assessment Point ($F(1,101) = 39.80$, $p < 0.001$, $\eta_p^2 = 0.28$), reflects an average decrease in this measure of general attentional bias to food cues over time. Importantly, however, this main effect was moderated by Group, as evidenced by a significant interaction of Assessment Point x Group ($F(1,101) = 23.39$, $p < 0.001$, $\eta_p^2 = 0.19$). As can be seen from Figure 4, this interaction reflected the fact that the decline in general attentional bias scores, from baseline to post-training assessment, was observed only in the training group. Post-hoc paired samples *t*-tests indeed showed no significant change between baseline and post-training in the control group (*t*(51)=-1.06, *p* = .294, Cohen's *d* = 0.15), and a significant decrease in the training group (*t*(50)=-7.74, *p* < .001, Cohen's *d* = 1.09).

Table 5. Mean general attentional bias, attentional engagement bias and attentional disengagement bias scores indexing attentional bias to food cues on baseline and post-training

	Control group (*n* = 52)				**Training group (*n* = 51)**			
	Baseline		**Post-training**		**Baseline**		**Post-training**	
	M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
GAB Index	43.22	286.06	-6.32	207.39	-28.10	302.66	-403.14	306.66
AEB Index	-241.18	430.69	-355.44	378.52	-222.09	332.49	-323.75	293.42
ADB Index	365.11	423.53	494.49	382.91	372.90	436.06	311.57	358.20

Note. GAB Index = general attentional bias to food cues as measured with the visual search task, AEB Index = index of increased attentional engagement with food cues as measured by the odd one out task, ADB Index = index of impaired attentional disengagement from food cues as measured by the odd one out task.

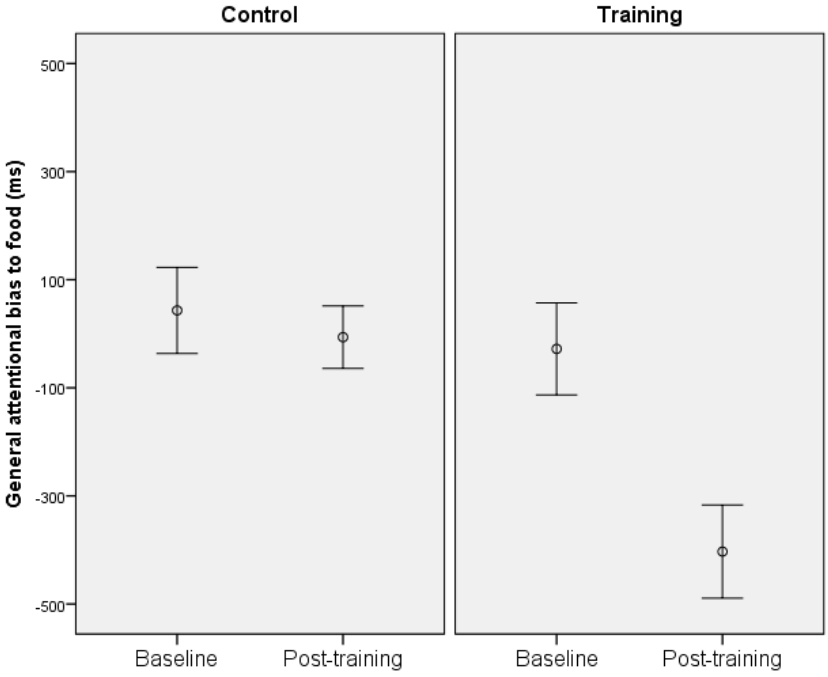
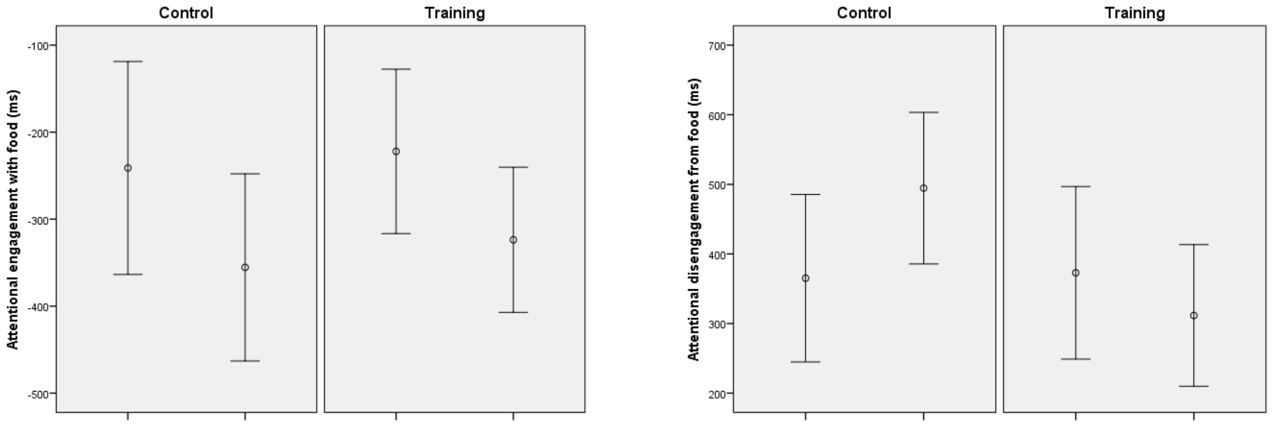


Figure 4. Mean general attentional bias scores (with 95% error bars) as measured by the VST at baseline and post-training assessment points.

Effect of BITT on biased attentional engagement with, and disengagement from, food cues

Mean attentional engagement bias and attentional disengagement bias scores obtained by participants in each group are shown in table 5. On the analysis carried out on attentional engagement bias scores, the only significant effect was the main effect of Assessment Point ($F(1,98) = 5.40$, $p < 0.03$, $\eta_p^2 = 0.05$), reflecting the fact that attentional engagement bias scores generally decreased between the two assessment points. The absence of a significant interaction between Assessment Point x Group (*F*(1,98) = 0.02, *p* = 0.89, η_p^2 = 0.00) revealed that this reduction in attentional engagement with food cues did not occur to a greater degree in the training condition that in the waitlist control condition (see Figure 5A). Post-hoc paired samples *t*-tests indeed showed no significant change in attentional engagement between baseline and post-training in the control group (*t*(49)=-1.60, *p* = .116, Cohen’s *d* = 0.23), or in the training group (*t*(49)=-1.71, *p* = .094, Cohen’s *d* = 0.24).

In contrast, the analysis carried out on attentional disengagement bias scores yielded no main effect of Assessment Point (*F*(1,98) = 0.50, *p* = 0.48, η_p^2 = 0.01), but instead now revealed an interaction between Assessment Point x Group (*F*(1,98) = 3.92, *p* = 0.05, η_p^2 = 0.04). As shown in Figure 5B, in the training group the attentional disengagement bias scores tended to decline from baseline to post-training, whereas no such decline was evident in waitlist control group (scores actually moved in the opposite direction). Post-hoc paired samples *t*-tests showed that there was a significant decrease in attentional disengagement from food cues between baseline and post-training in the control group (*t*(49)= -2.18, *p* = .034, Cohen’s *d* = 0.31), whereas the reduction in attentional disengagement from food cues in the training group was not significant (*t*(49)= -0.81, *p* = .423, Cohen’s *d* = 0.11).



A) Engagement

B) Disengagement

Figure 5. Mean attentional engagement bias with food cues score, and attentional disengagement bias from food cues score obtained by the OOOT given at baseline and post-training (95% error bars).
Note. Lower attentional engagement scores reflects less attentional engagement with food cues, lower disengagement scores reflects more attentional disengagement from food cues.

Effect of BITT on craving and food intake

General food craving scores, and food intake during the final 24 hours of the study, are shown in Table 6. The only significant effect to emerge was the main effect of Assessment Point, ($F(1,105) = 27.184$, $p < 0.001$, $\eta_p^2 = 0.21$), reflecting the fact that general food craving scores decreased from baseline to post-training. This effect was not modified by Group, within a two way interaction of Assessment Point x Group ($F(1,105) = 0.696$, $p = 0.41$, $\eta_p^2 = 0.01$), meaning that the decrease in craving was no greater in the training group that in the waitlist control group. Nor was there a significant difference in food intake between the training group and the waitlist control group, when this was assessed post-training ($t(108) = 0.603$, $p = 0.55$).

Table 6. Mean general food craving scores at baseline and post-training, and food intake post-training

	Training group				**Waitlist control group**			
	Baseline		**Post-training**		**Baseline**		**Post-training**	
	M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
General food craving	68.29	21.20	60.39	19.63	66.68	20.71	60.96	21.14
Food intake (kcal)	-	-	1979.95	716.57	-	-	2066.33	785.01

Post hoc analyses: relation between strength of training effect and change in food craving and food intake

The impact of the BITT might have varied across participants, and the strength of the impact of the BITT might be related to the influence of the training on craving and food intake. To examine whether indeed there is a relationship between the impact of the BITT and food craving and eating behavior, we performed post-hoc correlational analyses. Change in BITT performance was indexed by standardizing and summing the BITT measures (level 3 and level 12, and switch and maintenance) to reflect a total improvement on the BITT. Higher scores thus reflect more improvement. Subsequently, correlational analyses were performed to examine the relationship between the improvement measure of the BITT, the change scores of general food craving, as well as between the BITT improvement score and food intake at post-test. With regard to food craving lower scores reflect larger reductions in food craving. No significant correlations were found between the size of the training effect and the changes between baseline and post-test food craving (r = -0.07, *p* = 0.62). Further, no significant correlation was found with food intake at post-test (r = -0.11, *p* = 0.41). Furthermore, changes in attentional disengagement as measured with the OOOT disengagement were also not related to changes in food craving (*r* = 0.04, *p* = 0.70) or food intake at post-test (*r* = -0.12, *p* = 0.25).

Discussion

The current study aimed to examine the capacity of a modified Bouncing Image Training Task (BITT) to enhance attentional disengagement from food cues in unsuccessful dieters resulting in three aims. The first aim was to test the hypothesis that the BITT would serve to generally reduce AB to food cues in unsuccessful dieters. The second aim was to test the hypothesis that the BITT would exert its impact specifically on attentional disengagement bias, serving to enhance attentional disengagement from food cues in these unsuccessful dieters, without altering attentional engagement with food cues. Finally we aimed to determine whether the BITT served to reduce food craving or food intake in this sample. Unsuccessful dieters performed a daily 10-minute BITT for one week, and were compared with a waitlist control group. Participants who completed this ABM showed a moderate to large improvement in performance on the BITT across the week, which is reassuring but also unsurprising. Of greater importance, those who completed the BITT across this one week period also evidenced a decrease in general attentional bias to food as measured with the VST. Moreover, the attentional impact of the BITT was indeed specific to biased attentional disengagement from food cues. Participants who completed the BITT across the one week period of the study, compared to the waitlist condition, evidenced a relative increase in attentional disengagement from food cues whereas these groups did not differ in terms of attentional engagement with food cues. No effects of the BITT were found on measures of either food craving or caloric intake.

Increasing attentional disengagement from food cues could plausibly make it easier for unsuccessful dieters to resist food, thereby making their dieting attempts more successful. Previous studies using the visual probe ABM approach have shown some promise (Boutelle et al., 2014; Kakoschke et al., 2014; Kemps et al., 2014, 2016). However, this type of ABM approach cannot specifically target attentional disengagement bias. Therefore, the current study examined the capacity of the BITT approach to specifically increase unsuccessful dieters' ability to disengage attention from food cues. Participants who followed the BITT training for a week not only showed a medium to large improvement in BITT performance, but also demonstrated the intended change in selective attentional responding to food-related information.

Compared to participants in a waitlist control condition, those who completed the BITT training evidenced a greater reduction in general AB to food cues, as measured by the VST. In the waitlist control group, general attentional bias to food cues remained stable, whereas the training group showed a significant decrease in this general attentional bias across the week of the study. Selective attentional engagement with food cues, as measured by the OOOT, did not differentially change across this time period in participants who completed the BITT and those in the waitlist control condition. However, participants who completed the BITT showed a relative decrease in attentional disengagement from food cues. That is, whereas the control group demonstrated reduced attentional disengagement from food cues at post-test, the training group did not show this effect. Thus, it appears that the BITT training altered only attentional disengagement from food cues. Even so, this change did not reflect an absolute decrease, but a relative decrease when compared to the control group. The improvement in attentional disengagement from food cues can thus be considered fairly small, perhaps suggesting that completing a daily 10-minute session of the BITT for only one week might not be sufficiently to exert a large impact on this AB. Nevertheless, the present study provides preliminary evidence that the BITT can specifically enhance attentional disengagement from food cues.

As a final step, we examined whether the unsuccessful dieters who completed the BITT demonstrated a greater decrease in craving or food intake than did those in the waitlist control condition. In fact, a large decrease in food craving was found across both groups of participants, with no group difference in magnitude of this decrease. It might be that merely taking part in a study designed to change eating behavior exerts a large effect on participants' self-reported food craving, obscuring any subtle effects that the BITT may have on this measure. The current study also included a 24-hour dietary recall interview to assess real life food intake across the final 24 hours of the study. Again, no difference was found between the participants who completed the BITT, and those in the waitlist control group. Furthermore, post-hoc examination showed no relationship between the strength of the training effect in terms of change in BITT-performance and reduced disengagement bias from pre to post-test and the change in food craving or food intake at post-test. Hence the obtained pattern of findings suggests that increasing attentional disengagement from food cues does not necessarily serve to reduce food craving and food intake. Alternatively, it might be that adaptations are required to enhance the training effect of the BITT. Previous ABM procedures were based on the visual probe tasks and relied on implicit learning processes (i.e., participants were not explicitly instructed that they should avoid food cues). Analogous to other recently developed intervention tasks such as the positive search training (e.g., Waters, Pittaway, Mogg, Bradley, & Pine, 2013), the BITT explicitly teaches individuals to avoid attending to the food cues during the task. Since, it has been suggested that verbalization of strategies enhances self-regulated learning (Waters et al., 2015), this seems to be an important advantage of the BITT. However, it might be helpful to promote the goal-directed attention strategies even more explicitly by explaining that participants should focus on non-food items when confronted with tempting food stimuli (cf., Waters et al., 2019). Further, it must be borne in mind that it may take time for newly learned skills to generalize across real world contexts in ways that affect behavior, and so it is possible that the attentional bias modification delivered by the BITT might have delayed effects on eating behavior (Voogd et al., 2016). As such, a longer follow-up period might be needed to detect the potentially delayed effects of the BITT on food craving and food intake. Additionally, it is possible that the intensity of the present BITT training schedule was not sufficient to drive change in real-life eating behavior. For example, it has been found that participants who were given ABM sessions across a five week period were able to withstand a chocolate advertisement, whereas participants who were given one training were not (Kemps et al., 2018). Even with longer exposure to BITT sessions of extended duration, it may be prudent to add this type of attentional bias modification approach to other treatments, such as consultation with a dietician, rather than as a stand-alone intervention for unsuccessful dieting. In this way, both dieting goals and more automatic biases in attentional processing can be targeted together, thereby potentially enhancing the effects in terms of improved eating behaviors.

The current study has some important strengths such as the large sample size, the selection of participants who were all self-indicated unsuccessful dieters, the inclusion of two attentional bias assessment tasks to evaluate the impact of the training on both attentional engagement and disengagement bias, and the experimental design. Nevertheless, some limitations also need to be considered. First, because the pattern of attentional bias displayed by these unsuccessful dieters was not compared with a control group at the outset, it is not possible to determine whether the participants displayed inflated attention to food cues at the start of the study. It has been argued that ABM may be less likely to be effective when an AB is not present prior to the intervention (e.g., Heitmann et al., 2017). We are unable to rule out the possibility that this may explain why the relative increase in attentional disengagement from food cues, exhibited by those who completed the BITT, was not accompanied by reduced food craving and food intake. Second, participants in the current study varied in terms of whether they were healthy weight dieters, or were overweight or obese. Although the study does not have adequate power to contrast these subtypes of participants, it is possible that the impact of modifying attentional bias to food cues may not be equivalent in healthy weight and overweight participants, and this should be kept in mind when interpreting the results. Third, the assessment tasks showed moderate internal reliability as estimated with Spearman Brown correlations, with the consequence that the tasks may not have been sufficiently sensitive to capture AB and changes in AB that occurred after training. Internal reliability might be improved in future studies by using personalized stimuli (Christiansen, Mansfield, Duckworth, Field, & Jones, 2015), delivering more trials, or employing a blocked task design (Ataya et al., 2012; Field & Christiansen, 2012). Last, test-rest reliability of the assessment tasks was poor in the current study. This has been suggested to negatively influence the observed effect of a training, and thus might have resulted in an underestimation of the training effect (e.g., Soveri et al., 2018).

In summary, the BITT proved to be effective in changing AB to food cues in unsuccessful dieters. Moreover, the reduction in AB to food cues exhibited by those who completed the BITT, compared to waitlist controls, was driven by a relative increase in attentional disengagement from food cues, rather than by reduced attentional engagement with food cues. This finding is important given that impaired attentional disengagement from food cues seems most directly implicated in unsuccessful dieting. Nevertheless, the relative increase in attentional disengagement from food cues exhibited by participants who completed the BITT was not accompanied by a relative decrease in food craving or intake.

Participants in the training group and the waitlist control group reported an equivalent decrease in food craving, while the groups did not differ in food intake post-training. Hence it is possible that impaired attentional disengagement from food cues makes no causal contribution to food craving or consumption. Alternatively, it may be that the magnitude of the increase in attentional disengagement from food cues, elicited by the brief ABM manipulation delivered in the present study, was not sufficiently strong to influence craving or consumption, over and above the impact of participating in a study investigating dieting success. Future extensions of this research should examine whether the impact of BITT training on attentional disengagement from food cues can be increased by delivering longer sessions across a more extended time period, and whether changes in food craving or food intake become evident when these attentional effects are intensified by such training regimes. For the moment, we can conclude that the BITT approach employed in the present study does exert a specific impact on the process of attentional disengagement, and serves to enhance attentional disengagement from food cues. Hence we suggest that this task may prove to be a valuable tool in future research designed to illuminate the causal contributions made by this particular AB to dysfunctional patterns of eating, and to evaluate the potential therapeutic benefits of directly modifying this specific facet of attentional selectivity.

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Appendix

Table A

Speed of movement and switching of the BITT per level

Level	**Movement speed of the images**	**Box shift speed**	**Interval speed**
3	47.50	6.28 – 9.10	1.82 – 3.82
6	55.00	5.20 – 7.75	1.55 – 3.55
7	57.50	4.84 – 7.30	1.46 – 3.46
8	60.00	4.48 – 6.85	1.37 – 3.37
9	62.50	4.12 – 6.40	1.28 – 3.28
10	65.00	3.76 – 5.95	1.19 – 3.19
11	67.50	3.40 – 5.50	1.10 – 3.10
12	70.00	3.04 – 5.05	1.01 – 3.01

Note. Movement speed of the images is expressed in pixels per second, Box shift speed is the speed of the switching of the image of interest to a different box and is expressed in seconds, interval speed is the speed of switching within the same category and is expressed in seconds.