Self-control conflict in the eating domain

A cognitive, affective, and behavioral perspective

Becker, D.

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CHAPTER 4

Approach Avoidance Training in the Eating Domain: Testing the Effectiveness across Three Single Session Studies

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The steep rise of overweight in large parts of the world demonstrates that a healthy lifestyle has become exceedingly difficult with palatable, energy-dense food being easily available and often too tempting to resist (Ng et al., 2014; WHO, 2015). The over-consumption of high-calorie food can cause severe health problems (e.g., heart disease, diabetes), which raises the acute question of how to help people change their eating patterns effectively. Research from outside the eating domain suggests that people can be trained to make healthier choices if they learn to automatically respond with avoidance movements to temptations (see Marteau, Hollands, & Fletcher, 2012). In the present studies we tested whether the training version of the approach-avoidance task (AAT-training; Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011) is effective in modifying automatic response tendencies towards tempting but unhealthy food.

Targeting Automatic Processes

Over the past years, dual-process models of health behavior have become increasingly influential in explaining why people often fail to control their behavior in accordance with their long-term health goals (Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004). According to those models, unhealthy choices stem from impulsive (i.e., automatically activated approach) behavior towards rewarding stimuli (e.g., a chocolate cookie) which unfolds too fast to be controlled on time by the relatively slower and more effortful reflective processes (Gladwin, Figner, Crone, & Wiers, 2011). Indeed, the more rewarding people find a particular food the stronger their approach behavior (Brignell, Griffiths, Bradley, & Mogg, 2009; Veenstra & de Jong, 2010), and the more likely they are to actually consume it (Hofmann, Gschwender, Wiers, Friese, & Schmitt, 2008; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010).

The dual-process conceptualization inspired a new class of interventions aimed at modifying automatic precursors of behavior (e.g., Friese, Hofmann, & Wiers, 2011; Veling, Aarts, & Papies, 2011; Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013). One of those interventions is the AAT-training which has proven successful at changing unhealthy approach biases in the alcohol dependency domain. In the AAT-training, participants repeatedly make avoidance movements (e.g., pushing a joystick) in response to pictures depicting critical stimuli (e.g., alcohol beverages) and approach movements (e.g., pulling a joystick) to stimuli from a contrast category (e.g., soft drinks). Wiers and colleagues (Wiers, Rinck, Kordts, Houben, & Strack, 2010) showed that after a single session of AAT-training, student participants had developed an avoidance bias to alcohol pictures (i.e., relative faster avoidance than approach responses), and successfully trained participants also consumed less alcohol in a subsequent taste test. The effect was replicated in a sample of alcohol-dependent patients and extended with the finding that training led to lower relapse rates at one year follow-up (Eberl, Wiers, Pawelczack, Rinck, Becker, & Lindenmeyer, 2013; Wiers et al., 2011).

In the food domain, the effectiveness of AAT-training has yet to be established. Some indirect evidence comes from Kemps and colleagues (Kemps, Tiggeman, Martin, & Elliott, 2013) who trained participants to associate words related to avoidance with chocolate pictures and found decreases in implicit preferences and craving for chocolate. No behavioral measures were taken though. A more direct application of AAT-training using joysticks (Fishbach & Shah, 2006, Study 5) found that participants subsequently made healthier snack choices. This latter finding is qualified, however, by a small sample, lack of baseline measures and other methodological weaknesses (e.g., approach-avoidance responses were not disambiguated by a perceptual zooming feature; see below). Taken together, existing evidence is suggestive rather than conclusive and calls for additional and more rigorous testing.

In the present studies, we apply AAT-training to the domain of healthy eating, and investigate whether training to avoid high-calorie food stimuli and approach low-calorie food stimuli changes (implicit and explicit) food preferences and eating behavior. Given the successful application of AAT-training against alcohol addiction (Wiers et al., 2011) one might hypothesize that training can also change food preferences. However, preferences for fatty and sweet food have a very strong innate basis (Drewnowski, 1997) and might thus be less easily adjusted than preferences for alcohol. Moreover, the category 'unhealthy food' is much fuzzier than 'alcoholic beverage' which implies that in the latter case stimulus response associations are more easily processed (Rosch, Simpson, & Miller, 1976). Accordingly, successful AAT-training of food preferences should not be taken for granted but needs to be empirically tested. Irrespective of the outcome, such tests will have high informative value to all researchers and clinicians who want to target automatic preferences for unhealthy food.

General Method

The present studies investigated the extent to which AAT-training can modify participants' implicit and explicit food preferences and eating behavior. To keep the sample homogenous with respect to general eating behavior and food-related attitudes, we only tested women (Rolls, Fedoroff, & Guthri, 1991). In three single session studies participants were randomly assigned to experimental AAT-training in which they learned to avoid pictures of unhealthy food or to sham AAT-training without systematic avoidance of unhealthy food stimuli. As previous research in this domain suggests (Rinck & Becker, 2007; cf. Neumann & Strack, 2000) actual approach versus avoidance movements during AAT-training should be disambiguated by visual feedback of pictures zooming in versus out, respectively. In fact, actual arm movements seem to be unnecessary which allows for the use of key presses as an alternative response mode (Peeters, Wiers, Monshouwer, van de Schoot, Janssen, & Vollebergh, 2012; see also Seibt, Neumann, Nussinson, & Strack, 2008).

Stimulus-specific approach-avoidance biases were assessed before and after the training phase. After the training we assessed differences in implicit preferences towards healthy and unhealthy food stimuli (Study 4.1: IAT, Study 4.2 and 4.3: affective priming task), explicit preferences (Study 4.1 and 4.2), and actual eating behavior (Study 4.1: snack choice, Study 4.3: food consumption). In Study 4.2 and 4.3 we also tested the moderating role of individual differences in impulse strength and diet goal strength.

Analysis plan. Stimulus-specific biases before and after the AAT-training were assessed by measuring participants' mean reaction times (RT) during push (i.e., avoidance) versus pull (i.e., approach) movements in response to pictures of either unhealthy food or control stimuli (Study 4.1 and 4.2: healthy food, Study 4.3: stationery objects). We computed mean bias-scores per assessment phase (bias-score$_{control}$ = control push – control pull; bias-score$_{unhealthy}$ = unhealthy push – unhealthy pull), with positive scores indicating an approach bias, and negative scores an avoidance bias. In all RT-tasks, data were prepared by excluding incorrect trials, RTs above 2000 ms or below 200 ms, and RTs three *SD*s above/below the mean RT of each participant (see Wiers et al., 2010).

To test whether the AAT-training affected participants' bias-scores, we conducted 2 (stimulus: unhealthy vs. control; within) × 2 (time: pre- vs. post-assessment; within) × 2 (training condition: experimental vs. sham; between) mixed model ANOVAs. Since previous AAT-research found the strongest effects on the critical stimulus group (i.e., alcohol), we additionally ran analyses for unhealthy and control stimuli separately. Mixed model ANOVAs were also used to assess the effect of training on implicit preferences. Between-group differences on explicit and behavioral measures were tested with independent sample t-tests (two-tailed). Throughout all analyses the level of significance was p = .050.

Study 4.1

Method

Participants. Fifty-two students participated for course credit or € 10. Sample size was determined based on Fishbach and Shah (2006). Due to a technical error the data of one participant were unusable reducing the sample to fifty-one (M_{age} = 20.47, SD = 2.34, $n_{\text{experimental}}$ = 26).

Materials and procedure. Participants signed informed-consent, reported their demographic information, their height and weight, and completed the following tasks in the respective order. The entire study was computer-based and took part in individual cubicles.

AAT-assessment/-training. Participants received the instruction to keep their forearms steady on the armrests of their chair, and hold a response stick in each hand. On top of each stick was a response button that could be pressed with the thumb of the respective hand. The task was to indicate as quickly and accurately as possible the format (horizontal vs. square) of individually presented pictures by making a right or left button press. In approach-trials, button-presses initiated the picture to zoom in thereby simulating a pull movement. In avoidance-trials, pictures zoom out thereby simulating a push movement. Picture format to trial type to response assignment was counterbalanced between participants. Half of the trials were always avoidance trials, half were approach trials. The task started with 20 practice trials. Then participants completed 80 pre-assessment trials in which they avoided equal numbers of unhealthy and healthy stimuli, followed by 360 experimental/sham trials (experimental: avoidance of 90% unhealthy stimuli and 10% healthy trials; sham: proportion identical to pre-assessment), and finally another 80 post-assessment trials (proportion identical to pre-assessment). Participants saw in total 12 high-calorie pictures (e.g., a plate with chips) and 12 low-calorie pictures (e.g., a plate with carrots; taken from a validated stimulus set, Charbonnier, van Meer, van der Laan, Viergever, & Smeets, 2016). Food items from each category could be either sweet or savory, which did not affect analyses in any of the present studies. Half of the pictures presented in the experimental/sham and post-assessment phases were always novel with respect to the preceding phase. There were five equally distributed, self-timed breaks. Throughout all phases participants received accuracy feedback and had to correct inaccurate responses. Task completion time was approximately 15 minutes.

Implicit preference measure. Participants completed an IAT (Greenwald, McGhee, & Schwartz, 1998) to measure implicit associations between food-related words (healthy vs. unhealthy) and valenced words (positive vs. negative) and words related to either approach or avoidance. Because we only found a significant congruency effect (e.g., healthy-positive/approach was processed faster than healthy-negative/avoidance) we do not further discuss this measure. Interested readers can contact us for further information.

Explicit measure. To assess participants' propensity to make healthy life-style choices we presented ten short scenarios. At the end of each scenario participants chose between a healthy and an unhealthy option (e.g., "You are on a break between lectures, which of the two snacks would you get from the canteen? a) banana b) chocolate bar"). After individual item inspection, two items were identified as having low item discrimination (*D*s < .17; Ebel, 1954). The total number of healthy choices across the remaining eight scenarios served as dependent variable.

Behavioral choice. Subsequently, participants were invited to pick one of three different snacks (tangerine, granola bar, or chocolate bar – presented here in descending order of healthiness) as an additional reward for participation.

Exit interview. An oral funnel-debriefing method was used to test whether participants were aware of the aim of the study and the manipulation.

Two-week follow-up. Two weeks after participation, we emailed participants (49% response rate) and asked three questions about the frequency of health behavior in the past week ("In the last seven days, on how many days did you consume fresh fruit/consume ready meals/do sports."), and four questions about their health behavior (e.g., "In the last seven days I was eating healthily"; 1 = *completely disagree*, 7 = *completely agree*; $\alpha = .64$).

Results and Discussion

The data of two participants were incomplete which leads to deviating *df*s in the respective analyses. Participants' body mass index (BMI = kg/m²; $M = 21.57$, $SD = 2.67$) did not differ between conditions ($p = .234$), and did not significantly affect any of the analyses below.

AAT. Following our RT data preparation strategy, we excluded 6.90 % of all trials. The overall analysis did not reveal the predicted three-way interaction, $F(1, 48) = 2.52$, $p = .119$, $\eta_p^2 = .05$. Following up on our stimulus-specific hypotheses, we found a trend for group-differences in bias-score changes towards unhealthy stimuli, $F(1, 48) = 3.78$, $p = .058$, $\eta_p^2 = .07$. Bias-scores for unhealthy food stimuli tended to decrease in the experimental condition, $t(25) = 1.92$, $p = .066$, $d = 0.38$, but not in the sham condition, $p = .338$. This implies a somewhat larger change towards avoiding unhealthy food stimuli in the experimental condition only (see Figure 4.1, for descriptive statistics see Table 4.1). The same set of analyses for healthy stimuli did not reveal any significant effects (all *p*s > .400).

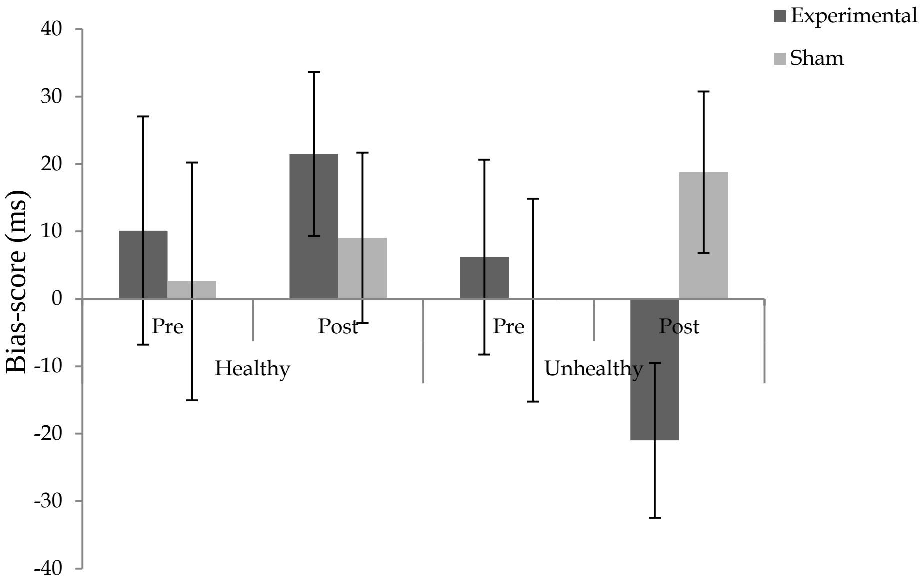

Figure 4.1. Study 4.1 (AAT), mean bias-scores (push – pull) in milliseconds per stimulus category (healthy vs. unhealthy), assessment phase (pre-vs. post-assessment) and condition (experimental vs. sham). Positive scores indicate an approach bias, negative scores indicate an avoidance bias. Error bars +/- 1 *SE*.

Explicit and behavioral measures. There was a trend for participants in the experimental condition ($M = 4.60$, $SD = 1.61$) to make healthier choices on the questionnaire than participants in the sham condition ($M = 3.79$, $SD = 1.47$), $t(47) = -1.83$, $p = .073$, $d = 0.52$. Participants' actual snack choice did not differ between conditions, $\chi^2(2) = 3.62$, $p = .164$. Follow-up measures revealed only one significant comparison: participants in the experimental condition consumed significantly less ready-meals in the last week than participants in the sham condition, $t(23) = 2.48$, $p = .021$, $d = 0.99$.

Additional analyses. First, we explored whether participants' relative bias-score at pre-assessment (Δ = unhealthy – healthy, higher scores indicating a stronger approach bias to unhealthy stimuli) moderated any training effects on the subsequent dependent measures (cf. Eberl et al., 2013). This was not the case (all *p*s > .100).

Following Wiers and colleagues (2010), we then compared successfully trained participants from the experimental condition (i.e., whose bias-score was lower at post-assessment compared to pre-assessment; $n_{\text{experimental}} = 15$) with the sham condition and found that the former more often chose the healthy option on the questionnaire ($M = 5.00$, $SD = 1.81$) than the latter ($M = 3.79$, $SD = 1.47$), $t(37) = -2.28$, $p = .028$, $d = 0.74$. Moreover, successfully trained participants also made healthier snack choices compared to the sham condition (tangerine vs. granola vs. chocolate: experimental 9 vs. 2 vs. 5, sham 4 vs. 9 vs. 12), χ^2 (2) = 7.65, $p = .022$.

Together, Study 4.1 provides only weak support for the effectiveness of AAT-training in changing implicit and explicit preferences for food. Only successfully trained participants made healthier hypothetical and actual food choices. Perhaps our design was not yet optimal to find stronger effects. First, it is possible that our study was underpowered if Fishbach and Shah's (2006) effect size was actually overestimated. On the basis of the effect-size observed in Study 4.1 ($d = 0.50$), we would need at least 102 participants to reach a power of .80. Second, possibly the AAT post-assessment phase, which technically resembles a sham training, weakened the training effect on subsequent explicit and implicit measures. In Study 4.2 we addressed those shortcomings.

Study 4.2

Study 4.2 was set up as a replication of Study 4.1 with an increased sample size and a number of methodological improvements. First, we measured implicit preferences between the (sham) training phase and the post-assessment phase. Second, as a measure of implicit preferences we replaced the IAT with an affective priming task, because responses in the IAT are more strongly influenced by the evaluation category labels than by the evaluation of the specific stimuli (De Houwer, 2001). Third, to improve the explicit measure, we dropped the non-functional items from the food-choice questionnaire and increased the amount of response options. Fourth, to explore whether AAT-training influences more the motivational or the evaluative properties of food stimuli we asked participants at the end of the study to rate all food stimuli used in the AAT on the liking and wanting dimension (Berridge, 1996). Finally, we measured individual differences in eating impulse strength, dieting goal strength, and general self-control. Impulse strength and goal strength might influence training effects (see Veling, Aarts, & Stroebe, 2013), while increased self-control might moderate the effect of implicit preferences on behavior (see Hofmann et al., 2008).

Method

Participants. One-hundred-sixteen students participated for course credit or € 7. We excluded twelve participants (N = 104, M_{age} = 20.77, SD = 2.94, $n_{experimental}$ = 52). Three because they had already participated in Study 4.1, seven because they had guessed the main hypothesis, and two due to technical error. The procedure and materials were identical to Study 4.1 except where noted.

Materials and procedure. Participants reported their hunger-level and how many hours ago they had eaten last.

Individual difference measures. Impulse strength was measured with the 21-item Power of Food Scale (α = .86; Lowe et al., 2009). To measure dieting goal strength, participants filled out the 6-item Concern for Dieting subscale of the Revised Restrained Scale (α = .75; Herman & Polivy, 1980), they rated how important dieting was for them (two items; α = .53), and their perceived dieting success (three items, α = .62; Meule, Papies, & Kübler, 2012). Self-control was measured with the 13-item Brief Self-control Scale (α = .83; Tangney, Baumeister, & Boone, 2004).

AAT-assessment/-training. AAT-training was identical to the one used in Study 4.1 except that responses were given on a keyboard by pressing the 'E' (approach) and 'I' (avoidance) keys with the index finger of the left and right hand, respectively. Key to response assignment was counterbalanced between participants. Moreover, implicit food preferences were assessed between the experimental/sham and the post-assessment phase.

Implicit preference measure. We used an affective priming task (Fazio, Sanbonmatsu, Powell, & Kardes, 1986) to measure implicit food preferences. Participants were instructed to indicate as fast and accurately as possible whether words presented on the screen were of positive or negative valence. They were further told that a directly preceding prime was not relevant for their response. There were three prime categories (pictures of healthy or unhealthy food, or stationery objects; three pictures per category; 2/3 of the food pictures were from the AAT-training phase), and two different target categories (positive and negative target words; eight words per category; all adjectives, e.g., nice, stupid). Prime pictures were visually matched for brightness and target words were similar in word length.

Table 4.1.
Mean AAT Bias-scores (Push – Pull) and Standard Deviations in Milliseconds as a Function of Stimulus Category, Assessment Phase and Condition in Studies 4.1 – 4.3.

		Control Stimuli		Unhealthy Food Stimuli	
		Pre	Post	Pre	Post
	Condition	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Study 4.1	Sham (*n* = 24)	3 (85)	9 (72)	0 (84)	19 (62)
	Experimental (*n* = 26)	10 (87)	22 (50)*	6 (62)	-21 (55) †
Study 4.2	Sham (*n* = 52)	28 (50)*	13 (52)	14 (47)*	5 (55)
	Experimental (*n* = 52)	11 (52)	16 (52)*	16 (59)†	10 (46)
Study 4.3	Sham (*n* = 51)	-55 (80)*	-39 (71) *	-9 (103)	-35 (67) *
	Experimental (*n* = 52)	-68 (99) *	-33 (74) *	-34 (93) *	-40 (115) *

Note. Control stimuli were healthy foods in Study 4.1 and 4.2, and stationery objects in Study 4.3.T-tests were carried out to test whether single cell bias-scores deviated from 0. Positive scores indicate an approach bias; negative scores indicate an avoidance bias. Bias-scores in Study 4.3 should be interpreted in relative terms due to a joystick specific artifact which led to all bias-scores being negative (see Larsen et al., 2014, for a similar observation).
† $p < .1$, * $p < .05$

Reliability was acceptable for positive target words ($\alpha_{healthy}$ = .47, $\alpha_{unhealthy}$ = .62) but very low for negative targets ($\alpha_{healthy}$ = - .04, $\alpha_{unhealthy}$ = -.02; Borkenau & Mauer, 2007). Since excluding any of the negative words did not improve the reliability substantially we continued with the present sets.

Participants started with eight practice trials and then completed 108 randomly presented experimental trials (18 trials per prime × target combination). Each trial started with the presentation of a fixation cross (for 1000 or 2000 ms), after which the prime was presented (size: 10 cm × 15 cm) for 200 ms and immediately masked by a black screen for 50 ms (SOA = 250 ms). The target appeared in the center of the screen (in capital letters) and remained there until the participant responded. Accuracy feedback was only given during the practice phase. Throughout the task, valence labels remained on the top left and top right of the screen. Halfway, participants took a self-timed break.

Explicit measures. We used an improved questionnaire from Study 4.1. Three scenarios were excluded and for the remaining seven scenarios we increased the response options from two to six (three healthy and three unhealthy options) and gave participants the opportunity to generate another option (7.50 % of all responses).

We further obtained liking ("How tasty do you find the food on the picture?") and wanting ratings ("How much would you like to eat the food on the picture right now?") for each picture used in the AAT-training. Participants responded on a visual analogue scale ranging from zero to hundred.

Results and Discussion

Neither participants' BMI (M = 21.01, SD = 2.79) nor any other individual differences differed between conditions (for BMI p = .224), and did not significantly affect any of the analyses below.

AAT. Following our analysis strategy, we excluded 7.26% of all trials. Neither the overall mixed model analyses, nor the stimulus specific analyses produced any significant effects (all ps > .150; see Table 4.1).

Implicit preference measure. As pre-determined in the analysis strategy, we excluded 6.80 % of all trials. A 3 (prime: healthy vs. unhealthy vs. control; within) × 2 (target: positive vs. negative; within) × 2 (training condition: experimental vs. sham; between) mixed model ANOVA on the mean RTs only produced a main effect of target, $F(1, 102) = 4.28$, $p = .041$, $\eta_p^2 = .04$. Participants generally responded faster to positive (M = 596, SE = 9) than to negative targets

($M = 605$, $SE = 11$). There were no differences between trained and untrained pictures.

Explicit measures. We found no difference between conditions in the amount of healthy food choices ($M_{experimental} = 2.98$, $SD = 1.35$; $M_{sham} = 3.19$, $SD = 1.60$; $t(102) = 0.73$, $p = .467$, $d = 0.14$), or in participants' wanting and liking ratings (all ps > .250).

Additional analyses. Neither self-reported individual differences in impulse strength, dieting goal strength, and self-control, nor relative bias-scores at pre-assessment significantly influenced the training effect in the AAT and on subsequent dependent measures (all ps > .050).

As in Study 4.1, we explored whether successfully trained participants ($n_{experimental} = 31$) show differences on any of the dependent variables when compared to the sham condition, which was not the case (all ps > .250).

Study 4.3

Study 4.2 did not reveal any signs of effectiveness of AAT-training in changing food preferences. In Study 4.3, we changed the set-up another time to create what we considered optimal circumstances for the effect to occur. First, we used pictures of chocolate as unhealthy stimuli and pictures of stationery objects (e.g., envelopes; pencils) as control stimuli to create less fuzzy training categories. Second, we only recruited participants with a strong desire for chocolate and intentions to reduce chocolate intake because previous research suggests that training might be most effective for people that find the stimuli motivationally relevant (Eberl et al., 2013; Veling et al., 2013). To further boost the hedonic response to chocolate, we induced craving before the training. Third, while Studies 4.1 and 4.2 used response keys (e.g., Peeters et al., 2012), Study 4.3 tried to strengthen the approach-avoidance experience by using a joystick. Finally, we replaced the single-act behavioral choice task from Study 4.1 with a bogus taste test. In comparison, the taste test is a rather unobtrusive behavioral measure and might thus be more prone to influences from implicit preferences.

Method

Participants. We recruited 104 students in return for course credit or € 10. We excluded one participant ($N = 103$, $M_{age} = 21.94$, $SD = 3.59$, $n_{experimental} = 52$) whose accuracy scores in the AAT and the affective priming task were extremely low (< 50% correct). Participants were asked to abstain from chocolate 24 hours before participation (Kemps & Tiggemann, 2009), and not to eat or drink sweet beverages up to three hours before participation (Segerstrom & Solberg Nes, 2007). The procedure and materials were similar to the previous studies except where noted.

Materials and procedure. Participants reported when they had last eaten chocolate and any food. We also asked them to rate their current chocolate craving and general hunger on scales from 0 to 100.

Individual difference measures. We used the same individual difference measures as in Study 4.2 (Concern for Dieting subscale α = .73; Importance α = .65; Success α = .62; Power of Food scale α = .88; Self-control scale α = .84), and added the 10-item Craving subscale of the Attitudes to Chocolate Questionnaire (α = .80; Benton, Greenfield, & Morgan, 1998).

Craving induction. To enhance chocolate-craving, all participants were presented with a plate of seven individually wrapped chocolates from which they were asked to choose their two favorites, to unwrap them and to stay engaged with them but to not eat them (Smeets, Roefs, & Jansen, 2009). After two minutes the chocolates were removed.

AAT-assessment/-training. The stimulus set comprised 30 pictures (15 chocolate, 15 stationery objects) derived from an online database and selected in a pre-test so that the two categories were similar in complexity (p = .838). Participants used a joystick to push or pull a picture away or towards them as indicated by perceptual feedback of pictures zooming out or in, respectively. The response defining format was changed from horizontal vs. square to tilted to the right vs. left (each picture was tilted by three degrees; see Larsen et al., 2014).

Participants first completed 16 practice trials, then 80 pre-assessment trials, 320 experimental trials, 80 post-assessment trials, and finally a refresh phase of 80 trials in which the responses contingencies were identical to the experimental phase. This last phase was added to maximize the training effect through counter-acting a possible neutralization of the training during post-assessment.

Implicit preference measure. The affective priming task was administered after the AAT-refresh phase. The task comprised only two prime categories: chocolate and control pictures (four per category, half were taken from the AAT-training phase). Targets were positive and negative words, matched for word length and with sufficient reliability for positive targets (α = .64) and negative targets (α = .53, after one negative target word was excluded). There were 8 practice trials and 128 experimental trials in total, and the fixation cross duration was kept constant at 1000 ms.

Behavioral measure. We used a bogus taste test adapted from Hofmann and Friese (2008) in which participants spent five minutes to taste and evaluate chocolate M&Ms (initial amount 125 g). The amount eaten was unobtrusively measured by a condition-blind experimenter.

Results and Discussion

Participants' BMI (M = 22.04, SD = 3.98) had no effect on any analyses and did not differ between conditions (p = .438). Conditions differed in self-control though. The sham condition reported higher self-control scores (M = 3.11, SD = 0.60) than the experimental condition (M = 2.77, SD = 0.66) , $t(101)$ = 2.77, p = .007, d = 0.54. No other individual differences differed between conditions, and, unless mentioned below, did not affect any of the analyses.

AAT. Following our analysis strategy, we excluded 5.69 % of all trials. The overall mixed model ANOVA yielded a main effect of stimulus, $F(1, 101)$ = 8.44, p = .005, η_p^2 = .08. Participants were generally more avoidant to control stimuli (M = -49, SE = 6) than to chocolate stimuli (M = -30, SE = 7). This effect was, however, qualified by a stimulus by time interaction, $F(1, 101)$ = 8.01, p = .006, η_p^2 = .07. Whereas there was no difference over time in the response to chocolate stimuli, $t(102)$ = 1.28, p = .204, d = 0.13, there was an increase in approach bias (or more correctly, a decrease in avoidance bias; see Table 4.1) to control stimuli, $t(102)$ = -2.32, p = .022, d = 0.23. In contrast to our hypotheses, condition did not have an effect.

Implicit preference measure. Following our analysis strategy, we excluded 6.90 % of all trials. We subjected mean RTs to a 2 (prime: chocolate vs. control; within) × 2 (target: positive vs. negative; within) × 2 (training condition: experimental vs. sham; between) mixed model ANOVA. We obtained a main effect of target, $F(1, 101)$ = 7.82, p = .006, η_p^2 = .07, with positive targets being generally reacted to faster (M = 567, SE = 9) than negative targets (M = 576, SE = 9), and a main effect of prime, $F(1, 101)$ = 6.32, p = .014, η_p^2 = .06, with responses being generally faster after chocolate primes (M = 568, SE = 9) than after control primes (M = 575, SE = 9). We also found a prime by target interaction, $F(1, 101)$ = 35.76, p < .001, η_p^2 = .26. Responses to positive targets were significantly faster than to negative targets when preceded by a chocolate prime (p < .001). However, when preceded by a control prime, responses to positive targets were slower than to negative targets (p = .046). The hypothesized three-way interaction was not found (p = .527). There were no differences between trained and untrained pictures.

Behavioral measure. A t-test revealed that – surprisingly – participants in the experimental condition (M = 31.44 g, SD = 17.95) consumed more M&Ms than participants in the sham condition (M = 23.98 g, SD = 14.01), $t(101) = -2.35$, $p = .021$, $d = 0.46$. The two conditions did not differ on their explicit evaluation of the M&Ms (all ps > .200). Since there was a significant relationship between self-control and M&M consumption ($r = -.22$, $p = .023$), and self-control scores were higher in the sham condition (see above) we repeated the analysis with self-control as a covariate, which reduced the effect to a trend, $F(1, 100) = 3.32$, $p = .072$, $\eta_p^2 = .03$. Those condition differences in M&M consumption were possibly a chance finding; alternatively they could signal a behavioral rebound effect (Erskine, 2008).

Additional analyses. We further found that self-control moderated the stimulus by time interaction on the AAT, $F(1, 99) = 8.77$, $p = .004$, $\eta_p^2 = .08$. Only for participants high in self-control (median split) did we find the stimulus by time interaction ($F(1, 54) = 15.40$, $p < .001$, $\eta_p^2 = .22$; low self-control $p = .596$). Participants high in self-control became more avoidant to chocolate stimuli, $t(55) = 2.30$, $p = .026$, $d = 0.31$, and more approaching to control stimuli, $t(55) = -2.78$, $p = .007$, $d = 0.37$.

We then tested if participants' relative pre-assessment bias-score influenced the effect of condition on subsequent dependent measures. This was only the case in the affective priming task (4-way interaction, $F(1, 99) = 8.74$, $p = .004$, $\eta_p^2 = .08$), which after more detailed inspection, however, appeared to be driven by two extreme cases in the sham condition.

When we included only successfully trained participants ($n_{experimental}$ = 15), all pattern of results remained the same.

General Discussion

The aim of the present research was to test the effectiveness of AAT-training in the eating domain. AAT-training has been successfully employed in the alcohol domain (Eberl et al., 2013; Wiers et al., 2010, 2011) and there is some preliminary evidence suggesting that it might also have beneficial effects on eating behavior (Fishbach & Shah, 2006; Kemps et al., 2013). Overall, across three single session studies using rigorous methods and sufficient statistical power we could not find conclusive evidence for its effectiveness in changing normal-weight participants' implicit or explicit food preferences and/or eating behavior.

In line with work in the alcohol domain, Study 4.1 supported the hypothesis that training changes response biases to unhealthy food stimuli and leads to healthier dietary choices, at least for the subset of participants who were trained successfully. However, Study 4.2, using a similar procedure but more statistical power, failed to reproduce those results. In Study 4.3 we adjusted our design to incorporate the recent finding that modification of implicit preferences is most successful when stimuli are motivationally relevant (Eberl et al., 2013; Veling et al., 2013). We therefore only invited participants with a strong desire for chocolate (and a general intention to reduce intake), and further maximized their hedonic impulse through a craving induction. All participants, independent of condition, became more approaching to control stimuli when measured on the AAT. For those high on self-control we also found an increase in avoidance bias for chocolate. In the affective priming task, however, all participants were more positive about chocolate, and participants' consumption in the taste test was higher in the experimental than in the sham condition, possibly due to coincidental between-group differences in self-control.

Together, our findings do not replicate AAT-training studies from the alcohol domain (Eberl et al., 2013; Wiers et al., 2010, 2011), nor the scarce evidence reported from the eating domain (Fishbach & Shah, 2006; Kemps et al., 2013). Although it is impossible to draw firm conclusions from null-findings, we can safely say that AAT-training effects, if they exist, are not as easily obtained for food as for alcohol, and that the reported evidence so far sketches an overly optimistic picture.

What could have prevented AAT-training effects to become apparent in our studies? We can preclude a variety of variables such as task characteristics, quality of measurement, and individual differences in impulse or diet goal strength. We can also rule out the explanation that unhealthy food is too fuzzy a category because Study 4.3 failed to train an avoidance bias towards the specific subcategory of chocolate. Four alternative explanations remain: perhaps training does not work effectively for normal-weight people. Unfortunately, previous studies (Fishbach & Shah, 2006; Kemps et al., 2013) do not report on their participants' BMI, which renders comparisons difficult. Since their studies were, however, also conducted in student samples, their BMI range was probably similar to ours. A second explanation could be that a single session, albeit sufficient to change alcohol preferences in heavy drinking students (Wiers et al., 2010), is not enough to influence people's powerful innate preferences for high-calorie food. These possibilities we currently address in a multiple-sessions AAT-training using a sample with a greater BMI range (www.impliciet.eu; see also Supplementary Material 2 for a preliminary analysis).

A third explanation could be that, unwittingly, the set-up or framing of the task have activated strong dieting goals that attenuated approach biases towards unhealthy stimuli. Pre-assessment bias-scores indeed show no evidence that our samples had strong initial approach tendencies to unhealthy stimuli, although in Study 4.3 pre-assessment bias-scores were actually relatively more favorable towards chocolate than towards control stimuli (see Table 4.1). On the other hand, however, pre-assessment biases are notoriously difficult to detect in the AAT irrespective of training effectiveness, and in the present studies, there was no indication of pre-assessment bias strength moderating training effectiveness (but see the study by Eberl et al., 2013, which found the moderation, probably because of sufficient statistical power, $N > 500$). We should thus be careful to conclude, solely based on pre-assessment scores, that a lack of unhealthy impulses prevented AAT-training to be effective. The activation of health goals can be expected to occur in many intervention studies (for a theoretical perspective, see Stroebe, van Koningsbruggen, Papies, & Aarts, 2013), and there is no reason to assume that this is particularly problematic for the effectiveness of AAT-training (Wiers et al., 2011).

A final reason why the present training was not effective could of course be that food preferences simply cannot be changed through automatic behavior training. This possibility seems to be unlikely, however, given the success of alternative implicit training methods (Veling et al., 2011, 2013).

Conclusion

Methods to change automatic response tendencies have become increasingly popular to improve people’s health. The current studies set out to test the effectiveness of AAT-training. While such training has proven effective in reducing implicit preferences for alcohol we could not find evidence that it works reliably in the domain of unhealthy food, at least not in single training sessions for normal-weight populations. We thus could not replicate preliminary evidence for successful training effects using similar techniques. Although we remain optimistic that AAT-training could eventually be used to make people’s eating choices healthier, our studies clearly show that we have yet a long way to go. Future research will benefit from our experience in the progress towards healthy eating.