Implicit drives toward healthy and unhealthy food: The effect of implicit training and sleep on eating behaviors

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Abstract

The obesity epidemic and the failure of existing dieting and exercise programs to combat it has pointed toward the importance of studying mechanisms behind eating habits. Previous research has suggested the significance of implicit biases on healthy eating behavior. This study created a single session Approach-Avoidance Task (AAT) training to further explore the potential of manipulating these implicit biases on eating behavior, and the liking and wanting of healthy and unhealthy food. 177 participants were assigned to approach healthy food, avoid healthy food, or a control condition. After the training, they gave ratings for their liking and wanting, and were presented with a food choice of apples, carrots, cookies, and chips. Quality of sleep was tested as a moderator of the effect of training on eating outcomes. It was hypothesized that: 1) Individuals trained to approach healthy food will develop a bias favoring the choice of a fruit or vegetable snack over chips or cookies, and 2) the training would be less effective for participants with worse sleep quality and more effective for those with better sleep quality. Trends in the data suggested that participants trained to approach healthy food had a decreased wanting for snack food and sweets. There was also a trend suggesting that participants with better sleep quality in the approach condition wanted unhealthy food the least. Results suggest the complexity of eating motivations and the importance of continued research on the role of unconscious processes and sleep in the context of eating behavior.

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Obesity and Shortcomings of Dieting

In the United States, the obesity epidemic is a major health issue. As of 2010, more than two thirds of adults are considered overweight or obese; half of these adults are obese. Furthermore, approximately one third of children and adolescents six to nineteen-years-old are considered overweight or obese. The numbers have continued to increase. Because obesity is a risk factor for diabetes and heart disease, it is imperative to discover and implement methods to treat and combat the obesity epidemic (U.S. Department of Health and Human Services, 2012).

Dieting is a primary method by which many overweight and obese individuals attempt to reduce BMI. However, most dieters fail to adhere to their regimen, possibly because people are biologically hardwired with automatic approach tendencies and positive affective associations towards food (Veenstra & de Jong, 2010). Evolutionary theory suggests that animals and humans developed positive associations toward high-fat food while it was more difficult to find, and humans have not yet adapted to the large availability of calorie-dense foods and less active lifestyle (Leonard et al., 2010). This evolutionary hardwiring may be difficult to combat with willpower alone as is the case in dieting. For example, although obese individuals know these calorie-dense foods contribute to poor health, they still are automatically drawn to the taste and exhibit preference for these foods (Roefs & Jansen, 2002).

Another important factor to consider is that priming may prove to be a hindrance to successful dieting, as readily available advertisements of unhealthy food may trigger automatic activation of hunger cues leading to the negative eating habits individuals attempt to avoid (Kakoschke et. al, 2016). Additionally, high calorie foods are readily available—in some cases more so than fruits and vegetables. This priming occurring in the modern, commercialized time, combined with the innate tendency to approach calorie-rich foods, may make it especially difficult to maintain a healthy diet focused on avoiding unhealthy food.

Significance of Implicit Biases in the Eating Domain

The role of these relatively automatic processes has made way for significant research on implicit versus explicit motivation for eating behaviors. The craving of energy-rich foods is considered to be an implicit process, as it is automatic and considered to be biologically hardwired. Effortful impulse control people exercise in order to inhibit and suppress this craving is considered to be explicit. More specifically, it is necessary to use conscious knowledge of the detrimental effects of a poor diet in order to exercise willpower to resist unhealthy food. Studies have found that participants with strong implicit biases favoring snack food and low inhibitory capacity gained the most weight over a one-year period (Nederkoorn et al., 2010; Kakoschke et al., 2015). Therefore, the interaction of these implicit biases with executive functions like self-control likely influences the success of dieting. Another study observed that those who had higher implicit tendencies favoring healthy food bought healthier food at a grocery store, while those implicitly favoring unhealthy food purchased unhealthier food—even when their explicit self-reports of liking foods were the same (Hollands et al., 2011). This result suggests a role in implicit biases in behavioral action in the eating realm. Because implicit biases have been seen to affect behavioral choices, further investigation is engaged to learn more about how they affect dietary preferences and behaviors.

Research suggests a measureable role of implicit processes on eating behaviors. Implicit biases may be measured in a number of ways, but one common method is the use of approach versus avoidance tasks. Specifically, implicit bias can be assessed by the amount of time it takes for an individual to approach or avoid to a certain food stimulus, typically normalized by subtracting that time from the amount of time taken to respond to a picture of a neutral non-food stimulus (such as pictures of clothes or animals). Approach and avoid reaction times may then be compared to measure that individual's implicit bias. For example, overweight and obese men are slower at avoiding stimuli of high calorie snack food than normal weight men, which indicates that they have a harder time overcoming their existing response to approach snacks (Havermans et al., 2011). Similarly, Kemps et al. (2013) found that participants who responded faster to pictures of chocolate paired with approach words tended to report higher cravings for chocolate than those who responded more slowly to this pairing. These two studies suggest implicit biases toward food stimuli measured with approach-avoid tasks may be associated with eating behaviors and weight gain.

Implicit biases have also been seen to correlate with external eating, or the tendency to eat due to emotions or external cues—factors outside of hunger and satiety feedback mechanisms. Brignell et al. found that high external eaters show greater attentional bias to pictures of food (2009). Furthermore, high external eaters evaluated food more positively than non-external eaters, indicating explicit bias as well (Brignell et al., 2009). It is thus possible that implicit biases also contribute to the tendency to overeat beyond the point of satiety, which, in turn, may contribute to obesity. Additionally, females diagnosed with eating disorders have been seen to show greater negative biases toward food images than observed in healthy weight and clinically anxious controls, which is interesting to consider as negative implicit biases toward food in general may be involved in a psychopathological restriction of eating (Johansson et al., 2005).

Existing Paradigms for Manipulating Implicit Biases in the Eating Domain

Because results from studies indicate the relevance of implicit biases in explicit measures and behavior, several paradigms have been studied to manipulate people's implicit biases toward food. Additionally, executive cognitive processes have been found to be difficult to manipulate in eating behaviors; thus it may be more effective to focus on implicit processes in order to change behaviors more effectively (Sheeran et al., 2016). One method previously studied to train implicit biases is a picture-picture evaluative conditioning task. By pairing pictures of high-caloric snacks with pictures of large torsos, thighs, and elbows, and pictures of fruits with "positively-valenced," lean body parts, there was a change in women's implicit associations with snack fruits (Lebens et al., 2011). Explicit measures of these women's liking of high-caloric food and fruits also indicates some level of learning from implicit measures, although there was no observable change in behavior.

Another method used to train implicit biases toward food is the implicit association task training, which is a type of training that pairs pictures of a stimuli with positive and negative words. When participants were trained to pair pictures of chocolate with positive words, they reported increased levels of reported craving for chocolate pre-training to post-training (Kemps et al., 2013). These findings indicate some level of implicit learning, which was translated to a change in explicit measures. Yet another method, called the go/no-go task, utilizes implicit learning by having participants push a button when they hear a tone. Folkvord et al. (2016) applied this task to children's eating behavior by having the tone play at the presentation of healthy food but not with unhealthy food and observed a decrease in snack food eating behavior. This task also led to decreased eating behavior in adults, whose weight decreased significantly between one and six months after four ten-minute sessions of go/no-go training (Lawrence et al., 2015). However, the change in behavior in children indicates that it may be possible to decrease snack eating behavior even without executive inhibitory functions most adults possess (Folkvord et al., 2016). This result is significant because it provides additional support for the potential of implementing implicit trainings to promote healthy eating without necessitating executive inhibitory functions as is the case in dieting.

The Approach-Avoidance Task and Existing Applications to Eating Behavior

A test and training method for changing implicit motivation is the approach-avoidance task (AAT), in which individuals either approach or avoid specific types of stimuli. Approach and avoidance processes are rooted in implicit animal learning and motivation (Roefs et al., 2011). The AAT may function at an even more implicit level when an individual's response to a stimulus is based on an unobtrusive content-irrelevant behavior, such as pushing or pulling a lever in response to the orientation of a picture containing pictures of food (Roefs et al., 2011). However, there is also evidence that participants can still be trained even when they know they are responding to the content of a picture in addition to its frame (Van Dessel et al., 2015).

The AAT has been utilized for measuring the implicit biases for food by examining normalized reaction times. For example, those who reported higher cravings for food also showed stronger automatic approach tendencies toward food than low food cravers in an AAT paradigm (Brockmeyer et al., 2016). Brockmeyer et al.'s study also observed that if approach bias increased due to increased exposure to food stimuli, so did levels of food craving, indicating the significance of the role of automatic tendencies in food craving and the potential to overeat. Fishbach and Shah's Study 2 (2006) used the AAT to see differences between dieters and non-dieters, finding that dieters were faster to push away food-related pictures than non-dieters. This finding is noteworthy because it indicates that learning may influence implicit biases. Higher order cognitive processes of dieters may have shaped their implicit avoid biases toward food cues. What has not been determined with certainty is whether manipulating implicit biases using the AAT would influence external biases and eating behavior. There is some evidence for this hypothesis from the alcohol abuse literature. Individuals being treated for alcohol use and dependence who were trained to avoid alcohol using the AAT showed a measurable decrease in levels of craving and drinking behaviors (Weirs et al., 2011). Therefore, the possibility of applying AAT training to eating behaviors became real.

Previous studies found mixed results on the effectiveness of AAT training for manipulating food craving and eating behaviors. Fishbach and Shah's Study 5 (2006) trained participants to push or pull food stimuli based on whether it was healthy or tasty. This study found that participants trained to approach healthy food and avoid tasty snack food were more likely to choose a healthy food option than those trained to avoid healthy food and approach tasty food. Becker et al. (2015) examined whether a similar effect could be obtained based on response toward the orientation of a picture, as opposed to its actual content. Their procedure was conducted with ten percent inconsistent stimuli (a 90:10 contingency ratio, as opposed to 100:0 ratio to reduce predictability of the task) in each condition. In this study, snack choice did not differ between approach healthy food and avoid healthy food conditions. It is possible that training is more effective when participants focus on the content of the pictures. However, it may also be possible that training is more effective when participants consistently approach healthy food and avoid unhealthy food without any inconsistent trials. Another possibility is that there is a certain amount of training trials participants must perform in order to produce a measurable change in eating behavior. Our study addresses questions generated from these findings by implementing a 100:0 contingency ratio and instructing participants to respond to the orientation of a picture as opposed to its content.

The AAT training has also been applied specifically to chocolate. One study found that participants trained to avoid chocolate ate significantly less of a chocolate muffin, and they tended to eat less food in total in comparison to those trained to approach chocolate stimuli (Schumacher et al., 2016). This study used the 90:10 contingency ratio, similar to Becker et al.'s procedure, with 240 training trials. However, another study from the same year found no statistically significant differences in amount of chocolate consumed using a procedure with a 90:10 contingency ratio and 320 training trials (Dickson et al., 2016). Considering results from these two studies, the extent to which the AAT may modify behavioral eating choices is inconclusive.

The Potential Effect of Sleep on Implicit Training

Perhaps one reason for the inconsistency in results across studies is the lack of attention to moderators of AAT on eating behavior. Given the known association between sleep and diet quality, a unique contribution of this study was to examine whether or not sleep quality moderated the effects of AAT on eating behavior. It has been observed that people may tend to utilize other sources of energy while sleep deprived (Alhola & Polo-Kantola, 2007). Therefore, those who have worse quality of sleep may have greater tendencies to choose calorie-rich foods over healthy options. Also, relevant cues may be overlooked individuals who are sleep-deprived participants are more easily preoccupied with peripheral concerns (Harrison & Horne, 2000). Thus, it is possible that sleep-deprived individuals tend to make unhealthy decisions despite the knowledge that healthy food is better for managing their weight and health because they do not have the cognitive resources to override urges to eat unhealthy but appealing foods.

There is little research on the effect of sleep on implicit trainings, but sleepiness has been observed to lead to either motivated top-down mechanism to counterbalance performance decline, or insufficient motivation to attenuate impairments and stay on task (Sarter et al., 2006). In other words, when a person is sleep-deprived, he or she will either summon increased focus in order to counteract cognitive deficits often caused by lack of sleep, or the individual will not have enough motivation to stay on task. Typically, performance during sleep deprivation deteriorates during simple, monotonous tasks requiring reaction speed or vigilance (Alhola & Polo-Kantola, 2007). Although implicit motivations may operate on a different level from cognition, it is possible that worse quality of sleep will affect implicit training similarly. Since the pulling and pushing of a lever in response to orientation of a picture may not seem to require considerable attention, it is possible that individuals would not have enough motivation to activate the top-down motivation to counter performance decline. However, it was also observed that implicit measures were predictive for food intake in the case of low cognitive resources (Friese et al., 2008). Therefore, if the AAT successfully trained implicit motivation toward food, it would be likely that lower quality of sleep would further facilitate the implicit training. Given these two possibilities that better sleep could either facilitate or deter AAT training in the eating domain, this study aims to determine which outcome is more likely to occur by examining the role of sleep as a moderator.

Hypothesis of the Study

It has been observed that people typically motivated by avoidance goals (e.g., don’t eat cake) tend to perceive less goal progress and tend to experience less positive effects and life satisfaction, and people who focus primarily on approach goals (e.g., eat more carrots) are more likely to evaluate themselves positively (Otis & Pelletier, 2008). Therefore, the method developed in this experiment was aimed at approaching healthy food, which has previously led to decisions to eat healthier food over unhealthy food (Fishbach & Shah, 2006). Stice et al. (2016) suggested it may be useful to compare methods that train the avoidance of high-calorie foods with the approach of healthy foods to better understand the mechanisms of implicit trainings. With these ideas in mind, it was hypothesized that when participants were trained to approach or avoid healthy food: 1) Individuals who are trained to approach healthy food will develop a bias that favors eating healthier foods than those who are trained to avoid healthy food, and 2) lower quality of sleep may inhibit the effectiveness of training, whether it be approach or avoid healthy foods.

Method

Participants

A total of 177 individuals participated in this study. Participants were recruited from the General Psychology 1001 class subject pool, and they were eligible to participate if they did not indicate any food allergies in the pool's prescreening survey. For participating in the study, participants earned two credits that counted toward their class requirement of ten research study credits. There were 82 females, 93 males, and 2 other or not identified. These participants were undergraduate students, most of them in their first year (70.1%), and some in the second (19.8%), third year (3.9%), fourth year (3.9%), and fifth year (1.7%). Participants' ages ranged 18-25 years-old (M_{age} = 18.9, SD_{age} = 1.3). The majority of participants identified as white or Caucasian (78.9%), but some identified as Hispanic or Latino (8.5%), American Indian or Alaskan Native (1.5%), African American or black (1.5%), Native Hawaiian or Pacific Islander (2.5%), and Asian (9.0%).

Design

This study was designed to be a single-session randomized experiment in which participants were assigned a training AAT to approach healthy food, avoid healthy food, or a control condition. Independent variables were condition assignment (approach fruits and vegetables, avoid fruits and vegetables, or control condition) and quality of sleep (as participants responded to the Pittsburgh Sleep Quality Assessment—a higher score indicates worse quality of sleep). Dependent variables included participants' rating of their wanting of healthy or unhealthy foods, whether they ate or did not eat when presented with a food choice, and if they ate, whether their food choice was healthy (apples or carrots) or unhealthy (chips or cookies).

Chi-Squared analyses were conducted to determine whether condition assignment affected participants' food choice at the end of their sessions. ANOVAs and pairwise comparisons were conducted to examine whether condition assignment affected the liking and wanting of healthy and unhealthy foods. This study also used linear regression models to examine the interaction between condition assignment and quality of sleep on measures of liking and wanting.

Procedure and Measures

When participants came into the lab, they were greeted by a researcher, who administered the written informed consent process. Once participants gave their consent for being a part of the study, they were brought to a private room where they responded to various questionnaires administered on a computer through REDCap software, including a dietary questionnaire on their eating behaviors the past week and their current level of hunger.

The AAT was programmed in ePrime, and participants used a Logitech Extreme 3D Pro Joystick to respond to a set of images, which would get larger when the joystick was pulled and shrink when the joystick was pushed. To avoid explicitly telling participants their condition assignment, they were instructed to push or pull the joystick based on whether the pictures were horizontal or vertical. All participants completed a set of 20 training trials, where they practiced pulling and pushing gray boxes based on their orientation (horizontal or vertical). After the training was a total of 120 trials of the stimulus set, which consisted of 15 images from each food category (fruits, vegetables, sweets, and salty snacks). These images were presented in color on a white background. Participants responded to each food image twice. If a participant performed the incorrect action (for example: pushing an image when it was supposed to be pulled), the screen would display a red "X" indicating the wrong response had been made, and the participant would repeat the trial with the appropriate response before moving onto the next.

Participants were randomly assigned to three conditions for the AAT. The first condition was approach healthy food (N = 66), where participants used a joystick to pull pictures of healthy food (fruits and vegetables) toward themselves and push away pictures of unhealthy food (salty and sugary foods). The second condition for the AAT was avoid healthy food (N = 53), where participants used the joystick to push away healthy food and accept unhealthy food. The third condition was a control trial (N = 58), where the type of food was randomized for pulling or pushing away. However, participants were still instructed to respond to these pictures based on the orientation of the pictures. The orientation of the pictures was also randomized across participants, so that approximately half of participants in each condition pulled horizontal pictures and pushed vertical pictures, and vice versa.

After the training AAT, participants responded to additional questionnaires, including giving ratings of liking and wanting in response to the 60 food image stimuli used in the AAT. For example, participants were asked, "How much do you like this food in general?" and "How much do you want this food right now?" with a picture of snap peas. They then chose a response, from "Not at all (1)," to "Somewhat (4)," to "Very much (7)." There were numeric options between these options so that liking and wanting were measured on an ordinal scale. The food image stimuli to which participants responded were divided into healthy (fruits and vegetables) and unhealthy (sweet and salty snacks) categories. Participants' ratings were averaged based on food category to find liking for healthy and unhealthy food, and wanting for healthy and unhealthy food.

Participants also responded to the Pittsburgh Sleep Quality Index, which gave participants a score based on amount of time spent in bed, amount of time taken to fall asleep, amount of time actually sleep, average amount of times it was difficult to sleep due to various reasons (such as coughing, pain, uncomfortable temperature, snoring etc.), medication usage for aiding sleep, self-evaluation of energy during the day, and self-rating of sleep overall. The index included nineteen items, and higher scores indicated lower overall quality of sleep. When the Pittsburgh Sleep Quality Index was tested on 158 participants for reliability and validity, there was an overall group mean of 7.4 (SD = 5.1), and had a high degree of internal consistency (Cronbach's $\alpha = 0.83$) (Buysee et al., 1989).

When participants completed this second set of questionnaires, they were told by the researcher that the session was over. The researcher offered participants a food choice: apples, carrots, potato chips, or chocolate chip cookies. These foods were packaged, and shown to participants and their choice was recorded. Due to the deceptive nature of the food choice portion of the study, the research assistant then conducted a funnel debriefing to determine whether they suspected the hypothesis of the study and debriefed them on the purpose of the study.

This procedure was approved by the University's Institutional Review Board.

Results

There were a total of 177 participants in the study; 130 of these individuals participated in the food choice, 45 participants did not accept the snack offer, and two were not offered a snack due to experimenter error. Of the 130 who participated in the food choice, 92 chose a healthy snack and 38 selected an unhealthy snack. For detailed breakdown of food choice by condition, please see Table 1. Based on the 1-7 scale of liking and wanting, participants reported an average liking of 4.482 for healthy food and 2.536 for unhealthy food. Participants also reported an average wanting of 3.127 for healthy food and 1.227 for unhealthy food. Participants in the study had an average sleep score of 6.003. For breakdowns of average scores and standard deviations across conditions, please refer to Table 1.

Testing Effect of AAT Training on Eating Outcomes

To test hypothesis 1 regarding the effects of AAT condition assignment on food choice, chi-square tests of independence were performed. The relationship between condition assignment and whether the participants accepted a snack or not was not statistically significant [X^2 (2) = 1.928, p = 0.381]. Therefore, condition assignment did not influence whether participants chose to eat. Additionally, the relationship between condition assignment and whether participants (among only those who accepted food) chose a healthy or unhealthy snack was not statistically significant, [X^2 (2) = 0.0246, p = 0.988]. Therefore, condition assignment did not influence whether participants chose a healthy or unhealthy snack.

To test Hypothesis 1 regarding the effects of AAT condition assignment on liking and wanting ratings of healthy and unhealthy food oneway ANOVAs were conducted where condition (approach healthy food, avoid healthy food, or control) was the independent variable. There was no significant effect of condition assignment on liking ratings [F (1, 175) = 0.433, p =

0.509] or wanting ratings [*F* (1, 175) = 1.90, $p = 0.17$] for healthy food. There were also no significant effect of condition assignment on liking ratings [*F* (1, 175) = 0.013, $p = 0.908$] or wanting ratings [*F* (1, 175) = 1.202, $p = 0.274$] for unhealthy food.

Pairwise comparisons revealed that there were no significant differences between the approach healthy food and control conditions, nor the avoid healthy food and control conditions; there were also no significant differences for the liking of healthy nor unhealthy foods (see Table 2). Therefore, much of the later analyses are focused on the wanting of healthy and unhealthy foods in the approach and avoid conditions.

Planned pairwise comparisons were completed to examine difference in the wanting rates of healthy and unhealthy foods between the approach and avoid conditions. There was not a significant difference in wanting healthy foods for the approach and avoid conditions; $t(174) = -1.630$, $p = 0.105$. Therefore, condition assignment did not influence the wanting of healthy foods. There was not a significant difference in scores for wanting sweet and salty foods for the approach healthy, and avoid healthy conditions; $t(174) = -0611$, $p = 0.542$. Therefore, condition assignment did not influence the wanting of unhealthy foods.

Testing for the Interaction between AAT and Sleep Quality

Logistic regression tests were conducted to explore a potential interaction between quality of sleep and condition assignment on food choice. Among those who took a snack, participants' food choice (healthy or unhealthy snack) was regressed on experimental condition (approach or avoid), Pittsburgh Sleep Quality Index, and their interaction. The overall logistic regression model predicting snack acceptance in the full sample was not significant [$X^2(124) = 151.86$, $p = 0.712$]. There were no significant main effects of sleep score, (OR: 1.00, [0.850, 1.182], $p = 0.579$), condition assignment (OR: 0.785, [0.269, 2.231], $p = 0.309$), or their interaction (OR: 1.102, [0.940, 1.307], $p = 0.336$). Out of those who accepted a snack, we regressed whether participants accepted food or not on sleep score, condition assignment, and an interaction term. The overall logistic regression model predicting food choice was not significant [$X^2(115) = 136.65$, $p = -0.241$]. There were no significant main effects of sleep score (OR: 1.066, [0.873, 1.369], $p = 0.982$), condition assignment (OR: 2.039, [0.570, 8.815], $p = 0.650$), or their interaction (OR: 0.895, [0.696, 1.093], $p = 0.241$).

Multiple linear regression tests were also conducted to explore the interaction between quality of sleep and condition assignment on the liking and wanting of healthy and unhealthy foods (see Table 3). Participants' ratings of wanting healthy foods in response to photographs of fruits and vegetables was regressed on experimental condition, Pittsburgh Sleep Quality Index Score, and their interaction. There were no significant main effects of sleep score [$\beta = -0.044$, $t(114) = 1.103$, $p = 0.294$], condition assignment [$\beta = -0.174$, $t(114) = 3.303$, $p = 0.536$], or their interaction [$\beta = -0.006$, $t(114) = 0.021$, p = 0.886] on their wanting of healthy food. The ratings of wanting unhealthy foods in response to photographs of sweet and salty snacks was regressed on condition assignment, sleep score, and their interaction. The omnibus test of this model for wanting unhealthy food, though trending, was not statistically significant [$F(2, 114) = 2.011$, $R^2 = 0.253$]. There was no significant main effect of sleep score [$\beta = 0.417$, $t(114) = 0.867$, $p = 0.327$]. There was a significant main effect of condition assignment on wanting unhealthy foods [$\beta = -0.627$, $t(114) = 0.584$, $p = 0.027$], indicating that participants wanted unhealthy food less when they were in the AAT approach healthy food condition. There was also a significant interaction between sleep score and condition [$\beta = 0.090$, $t(114) = 4.582$, $p = 0.034$], which was coded such that better quality of sleep facilitated a decreased wanting of unhealthy foods in the approach condition (see Figure 1).

Discussion

This study was devised to test whether the AAT can produce significant changes in eating variables: liking and wanting of food and food choice between healthy (apples and carrots) and unhealthy (cookies and chips) snacks. Previous studies showed mixed results on the effectiveness of AAT training on behavior, and this study seeks to further characterize the extent to which the AAT may be used for promoting healthy eating by potentially manipulating participants' liking and wantings, and behavior. I had hypothesized that 1) participants trained to approach healthy food would have greater biases favoring healthy foods than those trained to avoid, and 2) worse quality of sleep would lead to a reduced effectiveness in AAT training in both the approach and avoid conditions.

The Effect of AAT Training on Eating Outcomes

Hypothesis 1 was not supported by these results. Participants who were trained to approach healthy food were not more likely to choose a healthy snack or report significantly greater liking or wanting of healthy food than participants who were trained to avoid healthy food. Similarly, those assigned to the avoid healthy food condition were not more likely to choose an unhealthy snack, nor did they report greater liking and wanting ratings for snack food. Additionally, there was no difference between conditions on whether or not participants accepted the snack offer. These results indicate that a single session of AAT training does not lead to behavioral change in the diet domain, and does not significantly affect an individual's cravings for unhealthy food.

Although the data did not support Hypothesis 1, they were consistent with Becker et al.'s (2015) findings, which saw that the AAT training with a 90:10 contingency ratio did not lead to a change in behavior. On the other hand, these findings did not support those from Fishbach and

Shah’s Study 5 (2006), in which participants trained to approach healthy food chose to eat healthier food. It is possible that responding to content of the picture produces more robust effects than responding to the orientation. It is also possible the time elapsed between these studies led to different priming effects. Perhaps there are currently more high-calorie food stimuli available in social media and advertisements than what existed over ten years ago. There is evidence that advertisements prime hunger activation and wanting of unhealthy options, so perhaps greater extent of food priming makes the AAT less effective for approaching healthy food and avoiding unhealthy food (Kakoschke et al., 2016).

The results from this study also were inconsistent with a previous study, which measured an increased level of craving for those trained to approach chocolate (Kemps et al., 2013). Self-reports of cravings may be comparable to this study’s measures of wanting healthy and unhealthy foods. However, participants’ wanting of salty food and sweets did not increase when they were in the avoid healthy food condition. It is possible AAT trainings must be for specific food group such as chocolate, as opposed to a general category of “salty snacks” or “sweets.”

Though results are mixed, it is possible that AAT trainings may produce changes in eating behavior, but it may be that the effects are very small, which would suggest that more statistical power is required to detect the effect. It could also be that more trials and/or multi-session trainings should be used for useful effects. For example, there is evidence that the go/no-go task led to changes in eating behavior and BMI for over a month in duration when participants underwent four trainings (Lawrence et al., 2015). Should Hypothesis 1 be re-tested, it may be beneficial to study the effects of having participants undergo multiple trainings and measuring any changes over a longer period of time.

The Interaction between AAT Condition Assignment and Sleep Quality on Eating Outcomes

Hypothesis 2 was also not supported by these results. The omnibus tests for modeling the interaction of sleep and condition assignment were not statistically significant. It was expected for worse quality of sleep to lead to greater likelihood of wanting unhealthy foods and greater likelihood of choosing an unhealthy food for its greater calorie content in attempt to gain more energy (Alhola & Polo-Kantola, 2007). Contrary to this expectation, there were no significant main effects for the quality of sleep on participants' liking or wanting of healthy and unhealthy foods, nor food choice. It is possible participants were made aware of eating behavior and food cravings while looking at the food images. Perhaps this conscious thought of healthy versus unhealthy food affected participants' responses, overshadowing effects of quality of sleep.

There was no significant main effect for condition assignment on food choice or the liking of healthy and unhealthy foods, as would be expected from results discussed above. It is notable that there was a trending effect for approach or avoid condition assignment on food choice when controlling for quality of sleep. Those who avoided healthy food reported greater wanting for unhealthy foods, though there was no significant trend for the wanting of healthy foods. The omnibus test for both models were not statistically significant, but these results could indicate that it is more difficult to implicitly train approach processes of healthy food than unhealthy food.

There was no significant interaction between condition assignment and Pittsburgh Quality of Sleep Index score for food choice nor the liking and wanting of healthy food. However, it is notable that there was a significant interaction between sleep quality and condition assignment for the wanting of unhealthy food. Those who approached healthy food were more likely to want unhealthy food when they had worse quality of sleep. Though this is suggestive evidence supporting Hypothesis 2, this effect would need to be replicated with larger samples to have more confidence in the finding.

Limitations and Future Directions

One limitation of the study was that the liking and wanting of food and food choice do not measure one’s implicit bias toward those foods. These measures are influenced by top-down functioning that inform participants of the health advantages of liking and wanting healthy options. Therefore, it may be beneficial in the future to also study the changes in reaction times as an accurate measure of implicit bias (Brockmeyer et al., 2016; Fishbach & Shah, 2006; Roefs et al., 2011). It would be important to then compare changes in implicit biases in reaction and changes in liking and wanting. There is a possibility the AAT can manipulate implicit biases but not enough to produce an effect on explicit measures. Therefore, more extensive research on the AAT’s manipulation on implicit biases, compared to explicit measures, would be important for determining the extent of practical use for using the AAT training for eating behaviors.

Additionally, our study involved a single training session. It was previously discussed that it may be beneficial to have participants undergo multiple AAT training sessions. It may be possible the AAT training can produce a learned behavior through implicit processes, but requires greater amount or frequency of training sessions to be effective.

Conclusions

A single session of AAT training did not influence participants’ liking or wanting of foods or choice of healthy or unhealthy food. There have been varied results in the ability to implicitly manipulate eating motivation and behavior, and this may have to do with individual differences in automatic processing and the various methods utilized. It is also likely that implicit training for eating behaviors is not as straightforward as it is for alcohol (Wiers et al., 2011). Approach biases toward high-calorie food is connected to evolutionary mechanisms for survival, whereas alcohol addiction is not necessarily rooted in survival. Results from this study suggest further examination of the role in sleep in manipulating implicit biases. Better quality of sleep may facilitate implicit trainings, and it is possible greater power is required to detect this effect.

Previous research suggests a significant role in implicit biases on healthy eating behaviors. However, these implicit biases may be complex as they are intertwined with environmental and biological factors. Continued research in this field is imperative for further understanding of the manipulation of implicit biases of eating behavior with the goal of eventually implementing a more effective training than what exists to improve dietary health.

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Table 1

Eating variables and sleep score collapsed across condition assignment

	Approach	Avoid	Control	Total
Food Choice - *percent by condition*				
Healthy	40.2%	25.0%	34.8%	92
Unhealthy	39.5%	26.3%	34.2%	38
Snack accepted	40.0%	25.4%	34.6%	130
Snack not accepted	31.1%	40.0%	28.9%	45
Liking and Wanting Scores - *Mean (SD)*				
Liking Healthy	4.507 (0.957)	4.555 (0.914)	4.385 (1.106)	4.482 (0.992)
Wanting Healthy	2.897 (1.190)	3.279 (1.193)	3.204 (1.423)	3.127 (1.269)
Liking Unhealthy	4.264 (0.999)	4.255 (0.977)	4.286 (1.087)	4.268 (1.021)
Wanting Unhealthy	2.404 (1.227)	2.548 (1.207)	2.655 (1.410)	2.536 (1.281)
PSQI Score - *Mean (SD)*	5.877 (2.472)	6.321 (2.472)	5.811 (2.550)	6.003 (2.612)

Note: Two participants were not offered a snack, so their data is not included.

Table 2

Planned comparisons on liking and wanting of unhealthy food across conditions.

	***t*-value**	***p*-value**	**df**
Liking Healthy			
Approach v. Avoid	-0.257	0.797	174
Approach v. Control	0.683	0.495	174
Avoid v. Control	0.897	0.371	174
Wanting Healthy			
Approach v. Avoid	-1.630	0.105	174
Approach v. Control	-1.340	0.182	174
Avoid v. Control	0.313	0.752	174
Liking Unhealthy			
Approach v. Avoid	-0.047	0.963	174
Approach v. Control	-0.119	0.905	174
Avoid v. Control	-0.158	0.875	174
Wanting Unhealthy			
Approach v. Avoid	-0.611	0.542	174
Approach v. Control	-1.089	0.278	174
Avoid v. Control	-0.439	0.661	174

Note: Pairwise comparisons were coded as: Approach (1) v. Avoid (-1); Approach (1) v. Control (-1); and Avoid (1) v. Control (-1).

Table 3

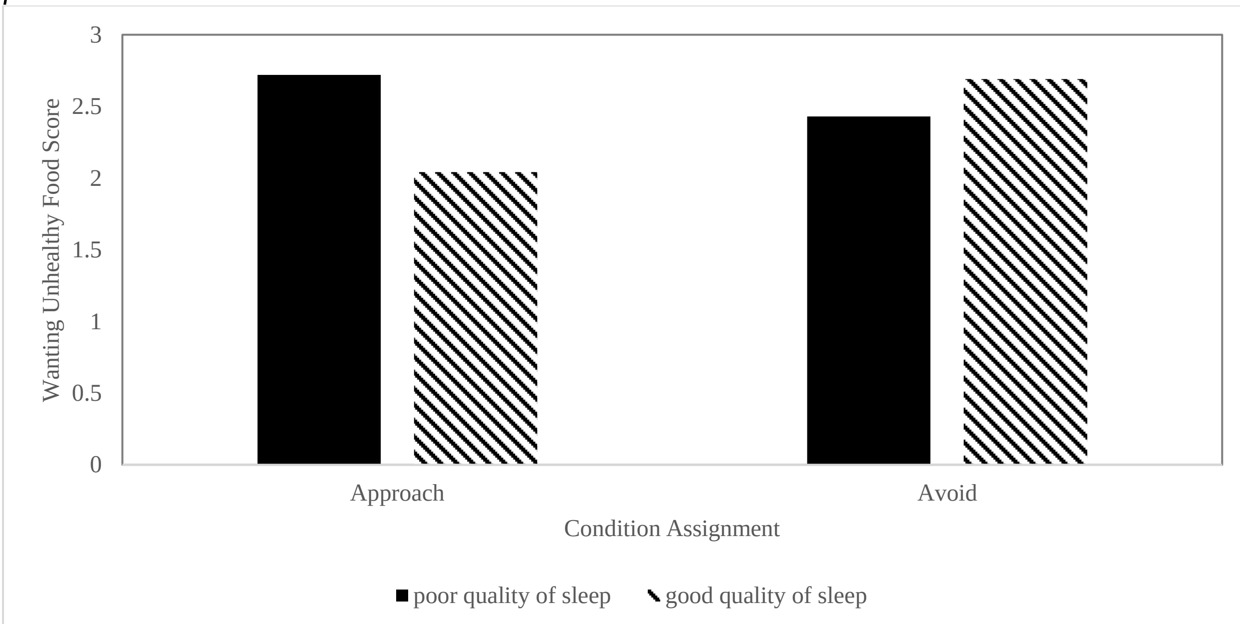
Multiple linear regression outputs of condition assignment, sleep score, and their interaction on liking and wanting scores

	Estimate (β)	**Test Statistic (*t*)**	***p*-value**	**df**
Liking Healthy		*F*=0.561	R^2 = 0.014	114
Condition effect	0.200	0.904	0.904	
Sleep effect	-0.021	-0.621	0.536	
Interaction	-0.037	-1.122	0.264	
Liking Unhealthy		*F*=0.421	R^2 = 0.011	114
Condition effect	-0.115	-0.493	0.623	
Sleep effect	0.034	0.966	0.336	
Interaction	0.021	0.596	0.552	
Wanting Healthy		*F*=1.475	R^2 = 0.012	114
Condition effect	-0.174	-0.621	0.536	
Sleep effect	-0.044	-1.053	0.294	
Interaction	-0.006	-0.143	0.886	
Wanting Unhealthy		*F*=2.011	R^2 = 0.253	114
Condition effect	-0.627	-2.236	0.027*	
Sleep effect	0.041	0.099	0.327	
Interaction	0.090	2.14	0.034*	

Note: A higher score on the Pittsburgh Quality of Sleep Index indicates worse quality of sleep. Condition assignment was coded so that approach was 1, and avoid was -1.

Figure 1

Effect of quality of sleep, condition assignment, and their interaction on wanting of unhealthy food.



Note: Poor quality of sleep and good quality of sleep were sleep scores one SD above and below the total mean across all conditions, respectively. Scores for wanting unhealthy food were derived by inputting these sleep scores, approach or avoid condition (coded as 1 and -1, respectively), and their interaction into the equation derived from their slopes (β) so that wanting unhealthy food score = 0.0417(sleep score) – 0.627 (condition assignment) + 0.090 (interaction score). Wanting scores were measured on a 1-7 scale, but this figure is scaled so that the interaction could be better observed.