Universiteit Leiden

Psychologie
Faculteit der Sociale Wetenschappen

Determinants of distorted approach behaviors towards food: a digital field study

Renske Rosa Brands, S1389564

Leiden University

Social and Organizational Psychology

First examiner: Hilmar Zech

Second examiner: Lotte van Dillen

September 2018

Table of contents

Abstract

The Western world is experiencing an obesity crisis that has left more than a third of the adult population overweight. In the current research, the mobile approach-avoidance task (AAT) was used to test approach biases in the food domain, to identify factors that distort rational food approach tendencies. That is, we aimed to identify factors that make people approach food even when they are not hungry. Thirty-two participants completed the experiment. During the AAT tasks, participants were shown food and object stimuli that they had to push away or pull towards themselves. As expected, we found that people were faster to pull food stimuli towards themselves than they were to push them away, in comparison to objects. We also found that this effect became stronger when people became hungrier. We did not find an effect of attractiveness of food stimuli, an interaction effect of hunger and attractiveness, or an interaction effect of hunger and susceptibility to the environment. The current research adds to the existing literature by showing the (robustness of the) approach-avoidance effect in the food domain and in the field, as well as a strong effect of hunger on these approach biases. A rational pattern of approach behaviors was thus found. This research lays the foundation for further investigations into the (ir)rational approach behaviors people exhibit towards food in their own environments. This could help us understand the psychological basis of the obesity crisis and may help to create or improve interventions to reduce this global health issue.

Introduction

The Western diet currently consists of many unhealthy foods containing too much fat, sugar and salt (Kakoschke, Kemps, & Tiggeman, 2015). This increases the risk of obesity or overweight when people's intake of these nutrients exceeds the amount that they actually need. Worldwide, the amount of obese or overweight individuals has more than doubled since 1980: in 2016, 39% of individuals over the age of 18 were overweight and 13% were obese (World Health Organization, 2016). Obesity and overweight have been shown to create health problems such as high blood pressure, heart disease, type 2 diabetes, and multiple forms of cancer (National Health and Medical Research Council, 2013).

Given these negative consequences, the rational thing for individuals to do, would be to avoid food when they are not hungry (Fishbach & Shah, 2006). Hunger would be a rational reason to eat. After all, we need to ingest enough nutrients to survive. However, psychological research shows that people often behave in an irrational manner (Kahneman, 2003). As shown by the worldwide rise in obesity, this irrational behavior might also be exhibited in the eating domain. For example, chocolate – even though it is bad for our health when ingested too often – has been shown to be one of the most craved foods in Western cultures (Kemps, Tiggemann, Martin, & Elliott, 2013). Thus, we eat and crave food that we know is bad for our health, even though there are other foods that could provide us with the nutrients we need. The question remains why. In order to contain or reduce the public health challenge of obesity, it is important to identify the underlying mechanisms of the obesity problem.

A part of the answer to the question why we behave irrationally when it comes to food, may lie in the environment we are living in (Swinburn, Egger, & Raza, 1999). Our environment is filled with constant reminders of (attractive) food. Our daily live consists of continuous exposure to pictures, sounds, and smells of food. Finding food has thus become easier than ever. This is what we call an "obesogenic environment" (i.e., an obesity-promoting

environment). The obesogenicity of an environment is defined as “the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations” (Swinburn, Egger, & Raza, 1999, p.564). This definition goes beyond the physical environment we live in (i.e., what is available). It also includes economic (i.e., costs), political (i.e., rules) and socio-cultural environments (i.e., attitudes and beliefs). However, it is important to note that an environment with an abundance of food is not a problem in and of itself. The problem lies in the fact that irrational behavior (i.e., eating food when the nutrients are not needed) is supported by the way the environment is shaped. After all, our environment makes it extremely easy to approach and consume food: there are supermarkets, restaurants and vending machines around us at all times. The possibilities to approach food are thus plentiful. An approach movement involves a decrease of distance between oneself and a target. The fact that we are experiencing an obesity crisis thus might mean that, somehow, our approach behavior towards food has become distorted. In the current research, we will investigate if and under what circumstances people exhibit distorted approach behaviors towards food.

Behavioral biases may be at the cause of this distorted approach behavior and the overconsumption of food (Schroeder, Lohmann, Butz, Plewnia, 2016). When people consistently act irrationally, this irrational behavior could be called a bias. Biases are considered to be automatic and difficult to control consciously. The current research will focus on a specific bias: the approach bias. An approach bias is an automatic behavioral tendency to move towards rather than to avoid a particular cue (Wiers, Gladwin, Hofmann, Salemink, Ridderinkhof, 2013); in the case of the current research: food cues. The fact that these processes happen automatically (i.e., outside of our awareness), makes it hard to resist their influence (Heatherton & Wagner, 2011). This can have great consequences though, since our environment is filled with food cues and the sight of food has been shown elicit high

attention to food cues, approach behaviors towards them and a desire to eat (Brignell, Griffiths, Bradley, Mogg, 2009). The automaticity of approach biases towards food might therefore be part of the cause of the worldwide rise in obesity.

Research has already shown that individuals often show a tendency to approach food (Brignell et al., 2009; Fishbach & Shah, 2006; Loeber et al., 2012; Paslakis et al., 2016). This can be explained from an evolutionary perspective; it certainly used to be an advantage to be able to quickly attend to food (Nijs, Muris, Euser, & Franken, 2010), and it has been shown that attention for palatable foods contributes to actual behavior, such as increased food intake (Kakoschke et al., 2015; Schroeder et al., 2016). However, as the rise in obesity illustrates, we sometimes behave irrationally when it comes to food as we approach food even when we do not need it. In the current research, we will measure these approach tendencies towards food with an approach-avoidance task (AAT; for meta-analyses see, Laham, Kashima, Dix, & Wheeler, 2015; and Phaf, Mohr, Rotteveel, & Wicherts, 2014). The AAT is based on the idea that positive stimuli elicit approach behaviors and negative stimuli elicit avoidance behaviors. This phenomenon has systematically been found in research and can be seen in many simple aspects of life: whereas people generally want to approach chocolate (Kemps et al., 2013), they generally want to avoid spiders, for example (Rinck & Becker, 2007). The first AAT used printed cards with positively or negatively evaluated words on them (Solarz, 1960). The experimenter gave participants the instruction to pull the cards towards themselves (i.e., approach) or to push them away (i.e., avoid). In the congruent condition, participants had to act in a way that was consistent with their evaluation of the words. That is, they had to pull positive words towards themselves and push negative words away from themselves. In the incongruent condition, participants had to behave inconsistently with their evaluation of the words. This means they had to pull negatives words towards themselves and push positive words away. Solarz found that people were faster and made fewer errors while making

congruent movements than while making incongruent movements. These findings were replicated with a computerized AAT that made use of a lever (Chen & Bargh, 1999). Again, people were faster to approach positive stimuli than negative stimuli and were faster to avoid negative stimuli than positive stimuli, which is called the *approach-avoidance effect.* This effect concerns responses (i.e., approach and avoidance movements) that have to be made as quickly as possible, which does not give people enough time to rationally think about the content of the cue. The subsequent expression of automatic behavior allows us to investigate whether these automatic behaviors are distorted and what factors affect this process.

The current research will make use of a newly developed method to study this automatic behavior (i.e., the approach-avoidance effect): the mobile approach-avoidance task (mobile AAT). The mobile AAT is a mobile version of the traditional AATs described before. It makes use of a smartphone application (app) that displays the stimuli on the screen of the smartphone. Participants are shown food stimuli that they have to approach (i.e., pull towards themselves) or avoid (i.e., push away). In a first test, the mobile AAT has replicated the approach-avoidance effect. That is, people were faster to pull happy faces towards themselves than they were to pull angry faces towards themselves, and vice versa for pushing the stimuli away from themselves (Zech, 2015). An important advantage of using the mobile AAT over a traditional AAT is the fact that the mobile AAT allows us to study participants' food approach biases multiple times in the field without the researcher and participants having to interact directly. Up until now, most research on approach-avoidance behavior has been conducted in the laboratory. By using the mobile AAT in the field, we will add to the existing literature on approach-avoidance behavior by studying people in their own environments. These environments are often highly obesogenic. The possibility to measure approach biases towards food in the field may therefore help to better understand (the cause of) the obesity crisis. Moreover, it is a critical advantage of the mobile AAT that it allows us to measure an

individual's food approach bias several times at different hunger levels, as this is not easily manipulated in the laboratory. This method thus allows us to test the effect of hunger on approach biases more easily.

Hunger is an important factor to include in this research, as the goal of this research is to answer the question whether people behave (ir)rationally when it comes to approaching food. As stated before, hunger would be a rational reason to eat. The rise in obesity, however, seems to suggest that there factors that drive people to approach food regardless of their hunger stage. We will therefore investigate two factors that could influence our behavior this way: the attractiveness of food, and people's susceptibility to external cues. These factors accommodate our vulnerability to our obesogenic environment: because attractive foods are all around us, being susceptible to external cues could magnify the impact of our environment on our rational eating behavior (i.e., eating when hungry). That is, it is a well known saying that we should not do our groceries while hungry, but perhaps this saying applies to our entire environment nowadays, and not just the supermarket.

If people would act rationally, this environment would not have a big impact. Rationally, we seek food when we are hungry as our body craves the nutrients that food can provide and ingesting them keeps us alive. Our body signals us of this need for food, which is what we call "hunger": a motivational factor that influences people's responses to food (Brockmeyer, Hahn, Reetz, Schmidt, & Friederich, 2015; Nijs et al., 2010; Seibt, Hafner, & Deutsch, 2007). Hungry individuals (compared to satiated individuals) show greater attention towards food and evaluate food more positively, leading to more food seeking, food intake and food purchase (Berridge, Ho, Richard, & DiFeliceantonio, 2010; Brockmeyer et al., 2015; Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009; Nijs et al., 2010; Seibt et al., 2007). The hungrier people become, the more positive their evaluation of food becomes (Seibt et al., 2007). This finding corresponds with research on rats: the hungrier rats are, the higher

is their motivation to obtain a reward (i.e., food; Brown, 1948). Even though both hungry and satiated people are faster to approach (pictures of) food than they are to avoid them, this effect is four times stronger for hungry individuals (Seibt et al., 2007). This effect, however, was found after one AAT session in a laboratory where participants used a joystick; the current research thus has the opportunity to add to this research by studying participants multiple times and in the field. The above-mentioned empirical findings lead to the following hypothesis:

H1. The hungrier individuals are, the stronger their food approach bias is.

Hunger is thus an important internal cue that tells people whether they need to eat, and would be a valid reason to approach food. However, as discussed before, a problem arises when people start (over-)eating when they are not hungry. Then there are other cues that influence people's decision to (over)eat. One such factor might be the attractiveness of the food cue. Due to our obesogenic environment, there are attractive food cues all around us. The attractiveness of these cues might trigger us to approach these food cues. In general, we might expect that people would rather approach a picture of fried chicken wings than a picture of a raw chicken wings. However, so far, not a lot of research has been devoted to this subject yet. Some studies on approach-avoidance behavior towards food have used pictures of attractive foods, though. Examples are desserts, pizza, hamburgers, chocolate, fruits, and salads. This research has shown that people are highly attentive towards pictures of (attractive) food, and are also fast to approach it (Havermans, Giesen, Houben, & Jansen, 2011; Nijs et al., 2010). Observing an appetitive stimulus creates a feeling of reward, which, in turn, elicits approach movements (Brignell et al., 2009). Havermans and colleagues (2011) showed that people were faster to approach attractive foods than they were to avoid them, and Fishbach and Shah (2006) found that people were faster to pull words related to attractive foods towards from themselves than they were to push them away. However, these studies did

not directly oppose attractive to unattractive food stimuli. The current research will add to the literature by studying people's responses to food pictures that differ in their levels of attractiveness. Above-mentioned findings lead us to hypothesize that:

H2. The more attractive the food stimulus is, the stronger the individual's food approach bias is.

The current research has, up to this point, focused on hunger and attractiveness as independent factors. So far, we have predicted that greater hunger will lead to a greater approach tendency towards food in general. Also, greater attractiveness of food stimuli will lead to a greater approach tendency towards these stimuli; irrespective of hunger. Importantly, these two factors might also have an interactional effect on food approach behavior. Because our obesogenic environment constantly surrounds us with food stimuli, this interactional effect of hunger and attractiveness of food stimuli might make us even more prone to overeat. This has not yet been studied before. Research has shown, though, that people rate food more positively when hungry (Lozano, Crites, Aikman, 1999) and positive evaluations can elicit immediate approach behaviors (Chen & Bargh, 1999). Lozano and colleagues' study did not distinguish between attractive or non-attractive food options. However, one might say that there is more to gain for unattractive foods than for attractive foods. This is a so-called "ceiling effect": when baseline scores are so high it would be difficult to show any real improvement (Wright, 1976). We argue that at a certain point, food cannot become more attractive than it already was; that there is a maximum to the attractiveness of a food stimulus and the effect it can have on our behavior. We thus expect that even though people show a higher general approach bias towards attractive food stimuli, the relationship between hunger and approach bias is weaker for these attractive stimuli due to a ceiling effect. In other words, there is a stronger relationship between hunger and approach bias for unattractive stimuli, since these food stimuli have more potential to increase in attractiveness when the individual

gets hungrier and then become new temptations that elicit irrational approach behaviors. This line of reasoning leads to the following hypothesis:

H3. The relationship between hunger and food approach bias is stronger for unattractive food stimuli than for attractive food stimuli.

The attractiveness of a food cue is created by an interaction between stimulus characteristics (i.e., the physical characteristics of the stimulus) and individual characteristics (i.e., preferences/attraction). In contrast, hunger is about a state of the individual. Whereas hunger is thus an "internal" influence, attractiveness is more of an "external" influence. These external influences are constantly around us and can elicit irrational behaviors. As discussed before, we are currently living in an obesogenic environment. Even when there is no real food around us, there is practically always some kind of food-related cue or advertisement in sight. This has far-reaching consequences, since research has shown that exposure to attractive foods increases approach behaviors towards food for mice (Liu et al., 2016). However, not every individual is influenced in the same way and to the same extent by these external influences. That is, personal differences in people's susceptibility towards the environment – and its abundance of food cues – might have an impact on their approach behavior towards food. This characteristic, being susceptible to external food stimuli in the environment, will be investigated in this research as well. This can be investigated by measuring individual differences in appetite-related thoughts, feelings and motivations, which is reliably done by the Power of Food Scale (PFS; Lowe et al., 2009). Research has shown that people who are not influenced as much by external food stimuli, behave in a way that we would consider to be rational: the hungrier they are, the faster they approach food (Zech, 2017). However, some people are influenced heavily by external cues. These individuals show different and sometimes reversed (i.e., irrational) effects of hunger on their approach biases (Zech, 2017). These findings lead to the following hypothesis:

H4. Individuals that are little susceptible to the environment show a stronger relationship between hunger and approach bias than individuals that are highly susceptible to the environment.

To summarize, the main goal of the current research is to create new insights into the workings of three specific factors (i.e., hunger, food attractiveness, and susceptibility to the environment) on people's responses to food. Hunger would be a rational motivation to approach food, but food attractiveness and susceptibility to external cues both play into our vulnerability to our obesogenic environment, which poses a threat to our rational eating behavior and thereby our health. The obesity crisis we are currently experiencing is a global health issue. This research aims to investigate whether people exhibit distorted approach behaviors towards food. If this is the case, the results of the current research may help to understand the psychological basis of the obesity crisis by identifying determinants of these distorted approach behaviors. This way, this research might help to create appropriate interventions in order to constrain or even reduce this problem.

Method

Participants

Participants for this study were recruited in the field through word-of-mouth advertisement and flyers at multiple buildings of Leiden University. Individuals between 18 and 30 years of age and of all gender identities could participate in the experiment. In total, 34 participants completed the experiment. Two participants were excluded from the analysis because they did not understand or follow the instructions correctly. Of the 32 participants in the analysis, 26 (81.3%) were female. Participants were between 18 and 26 years old, with an average age of 21.38 years (SD = 2.56). All participants were students at Leiden University.

Research Design

This experiment had a within-participants research design. The experiment consisted of an introduction session, three AAT sessions, a final session and a laboratory appointment. Except for the laboratory appointment, all measurements were conducted via an application and did not require any contact between the experimenter and participants. The three AAT sessions were conducted during breakfast, lunch, and dinner time. During an AAT measurement, participants were shown two types of pictures on their smartphone screen: food stimuli and object stimuli. Participants received both the instruction to pull food and push objects and the instruction to pull objects and push food during one AAT measurement.

Dependent variable. The dependent variable in the current research was reaction time. A participant's reaction time was measured in milliseconds and defined as the time between stimulus presentation and movement initiation.

Independent variables. There were five independent variables in the current research: response direction (push vs. pull), stimulus type (object vs. food), hunger, attractiveness and Power of Food score. *Response direction* described whether participants pushed or pulled the pictures. *Stimulus type* showed whether the picture was a non-food or food picture. *Hunger* showed the hunger level the participants were in at the moment of conducting an AAT measurement. *Attractiveness* showed the level of attractiveness that the participants assigned to a certain picture. The *Power of Food score* was a measurement of people's susceptibility of the environment.

Counterbalanced conditions. There were twenty-four counterbalanced conditions in this experiment. Participants were assigned to the counterbalanced condition that had the least amount of participants at the moment of downloading the app, or randomly if multiple conditions had the same amount of participants. This counterbalanced condition determined the order in which participants completed the AAT sessions (i.e., breakfast-lunch-dinner,

lunch-dinner-breakfast, or dinner-breakfast-lunch). Participants completed one AAT session during each of these three time frames. All participants conducted at least one AAT session before a meal and at least one AAT session after a meal, the order of which was dependent on their counterbalanced condition as well. The order of the instructions to either start pushing food and pulling objects, or start pushing objects and pulling food, was counterbalanced as well, to minimize learning or carry-over effects. However, the order of these instructions remained the same for each participant during each of their AAT measurements. Thus, whereas one participant always started with the instruction to pull food and push objects, another participant always started with the opposite instruction. A detailed overview of the counterbalanced conditions can be found in the Appendix (Table 1).

Instruments and Materials

Demographic questionnaire. The demographic questionnaire consisted of three questions about the participants' age, gender identity, and study/occupation.

Hunger measurement. The hunger measurement consisted of one question about the hunger state of the participants, using a response scale of 1 ('not hungry at all') to 5 ('very hungry').

Rating task. The rating task measured the attractiveness of the stimuli. The rating task consisted of one of the following two questions: "How attractive do you find this object?" (in case of an object stimulus) or "How attractive do you find this food?" (in case of a food stimulus). Responses were collected on a 5-point response scale, ranging from 'not attractive at all' (1) to 'very attractive' (5).

Power of Food Scale. The PFS is a measure of the psychological impact of living in an environment with attractive foods constantly available (Lowe et al., 2009). The questionnaire measures appetite-related thoughts, feelings and motivations that participants might have in response to the presence of food in their environment, which can be used to

examine participants' susceptibility to the environment. The PFS consists of 21 items on a 5-point response scale, ranging from 1 ('don't agree at all') to 5 ('strongly agree'). An example of a PFS item is: "If I see or smell a food I like, I get a powerful urge to have some" (Lowe et al., 2009, p. 115).

Stimulus set. The pictures used in this experiment were taken from the food-pics database (Blechert, Meule, Busch, & Ohla, 2014). This database contains both food pictures and non-food pictures. For all pictures, detailed data on image characteristics, food contents, and normative ratings are specified (Blechert et al., 2014). Based on the rating data, we selected food pictures using the cravings scores (i.e., how strong a person's "motivational state promoting the ingestion of the desired nourishments" is; Brockmeyer et al., 2015, p. 197) and recognizability scores (i.e., how easily the depicted food is recognized), as well as the healthiness of the food. That is, we only used pictures that were highly recognizable, and for both the highly and lowly craved food categories, we used pictures of both healthy and unhealthy foods. In total, 120 pictures were used in the AAT sessions. Of these pictures, 80 were pictures of food stimuli (20 healthy/attractive, 20 unhealthy/attractive, 20 healthy/unattractive, 20 unhealthy/unattractive) and 40 were pictures of object stimuli. Another 20 food stimuli and 10 object stimuli were used for practice trials.

AAT. The AAT consisted of trials. During a trial, a fixation dot would be visible for 1.5 seconds, after which the picture was shown and participants had two seconds to respond. Upon seeing the pictures on the phone's screen, participants either pulled their mobile phone towards themselves or pushed it away from themselves. Between trials, participants put their arms back at a comfortable position from which they could easily push and pull the phone again. The trials were divided over two blocks with different instructions. Before the instructions changed (from pushing to pulling and vice versa), participants completed practice trials in order to fully understand the task at hand. During practice trials, participants received

feedback through a green or red screen after following the instructions correctly or incorrectly, respectively.

The App

An app was specifically designed for the purpose of this study. Participants could download this app via the Play Store on Android (Android version 4.4 and higher). After opening the app, participants got to the home screen of the app. This screen consisted of five buttons that could bring the participants to the five experimental sessions that they had to complete in the app: the introduction session, three AAT sessions and final session. Clicking on a button would start the desired session. However, all buttons were inactive at the moment of downloading, except that of the introduction session. In order to avoid the problem of participants missing a session, participants were asked to put the sessions in the calendar on their phone. This could be done automatically by clicking on the closed sessions; the app would then redirect the participants to their calendar. The day after finishing the introduction session, the first AAT session was activated. The second AAT session only was activated after the first AAT session was conducted, and the third after the second was conducted. As the AAT sessions had to be conducted during breakfast (i.e., 6 am – 11.30am), lunch (i.e., 11.30 am – 4 pm) and dinner time (i.e., 4 pm – 11pm), the buttons to these AAT sessions did not work outside of those particular hours. After a participant had finished a session, the button to that session became inactive again and showed a green check mark behind the title. If a participant missed a session on a particular day (i.e., did not open and conduct the session during its time frame), the other AAT sessions would become active during their particular time frames that day, in order to reduce the chance of missing data. This way, participants could still complete all sessions, though not in the correct order according to their counterbalanced condition.

Introduction session. The introduction session consisted of reading and agreeing to the informed consent, reading an overview of the study and instructions for the AAT, and completing the demographic questionnaire and AAT practice trials. Participants had to complete seven practice trials for each type of instruction (i.e., push/pull food/objects) correctly before being allowed to continue with the experiment. If the participant incorrectly pushed or pulled during a practice trial, this trial would be repeated until performed correctly or until 20 trials were done.

AAT sessions. Each AAT session started with a repetition of the AAT instructions, followed by practice trials. Participants had to complete seven practice trials correctly before being allowed to continue with the experiment. Subsequently, the AAT measurement, consisting of 120 trials, was conducted. These trials were divided over two blocks of 60 trials, with a break in between (after 30 trials). The AAT sessions finished with the hunger measurement.

Final session. The final session consisted of the picture rating task and the Power of Food Scale. At last, participants were asked to contact the researchers via e-mail in order to arrange a lab appointment.

Procedure

Depending on the counterbalanced condition a participant was in, the total experiment could take up two or three days. After downloading and starting the app, participants could start the introduction session. After finishing the introduction session, participants could complete the three AAT sessions during their particular time frames. After completing all three AAT sessions, participants completed the final session. For this final session, participants did not have to wait until a specific time frame, but could start whenever they wanted to.

After finishing all tasks, participants made an appointment with the researcher in the lab. During this lab appointment, participants received a full debriefing (i.e., the goal of the research was told and questions were asked to investigate whether participants had understood the instructions correctly). Also, participants' BMI was measured for another study. Finally, participants received either a monetary reward of €20 or 6 participant credits for participating in this study. This research has been approved by the ethics committee of Leiden University.

Results

Exclusion Criteria

If a participant responded incorrectly to more than 20% of the trails in a particular AAT session, this session was excluded from the analysis. Participants who did not finish the final session or did not complete at least one AAT session were excluded from the analysis as well. Trials were excluded when participants used the wrong response direction (push instead of pull or vice versa), when there was no response, or when participants responded faster than 200 milliseconds. For the current research, this meant that two participants had to be excluded from the analysis for having a session error rate higher than 20% for all three sessions of the experiment, indicating they might have had difficulties following the task instructions or the application did not operate optimally. The first participant had error rates of 55.8%, 40.8%, and 47.5% respectively, whereas the second had error rates of 49.2%, 46.7%, and 47.5%. Furthermore, for one participant, one AAT session was excluded, due to an error rate of 20.8%, but the other two sessions were included in the analysis.

Preliminary Data Analysis

Counterbalanced conditions. Of all trials performed in this research, 5281 (50.1%) were performed before a meal and 5255 (49.9%) were performed after a meal. The balancing of instructions was adequate: for 6297 trials (59.8%), the first instruction was to pull food

towards oneself, whereas for 4239 trials (40.2%) the first instruction was to push food away from oneself. While slightly imbalanced, this counterbalancing condition decreases the influences of learning or carry-over effects. Based on this data, we can conclude that our method to creating counterbalanced conditions has been successful.

Assumptions. The assumptions of a mixed model regression are those of normality, independent errors, multicollinearity, homoscedasticity, and linearity. All of the assumptions have been checked and were met. Moreover, there are no influential data points in the data set that could distort our results.

Means and distributions

Hunger. Overall, participants had a mean hunger score of 2.51 (*SD* = 1.32). An independent t-test was conducted to compare hunger levels of participants that conducted the AAT session either before or after their meal. This analysis revealed that the mean hunger score of the participants that conducted the experiment before their meal (*M* = 3.46, *SD* = 1.07) was significantly different from the mean hunger score of participants that conducted the experiment after their meal (*M* = 1.58, *SD* = .76), *t* (10439) = 103.969, *p* < .01.

Attractiveness. Overall, participants rated the pictures with an average score of 2.94 (*SD* = 1.37) on a scale of 5. The mean attractiveness score differed for the two types of pictures participants were shown; food pictures had a mean attractiveness rating of 3.35 (*SD* = 1.29), whereas objects had a mean attractiveness score of 2.11 (*SD* = 1.12), *t* (10272) = 47.731, *p* < .01.

Power of Food Scale. Overall, participants had a mean PFS score of 2.87 (*SD* = .78) on a scale of 5. The PFS scores seem to be normally distributed.

Reaction time. The average reaction time of our participants was 456 milliseconds (*SD* = 152.79). The reaction times ranged from 201 to 1878 milliseconds. In the analysis,

transformed (i.e., inverted) response times were used, due to the fact that inverted reaction times are more easily interpretable and it makes the data more normally distributed.

Analysis

The AAT data were analyzed using a linear mixed model regression analysis with stimulus type, response direction, hunger, attractiveness, PFS scores, and hour as independent variables and reaction time as dependent variable. Hour of the day was added to the model in order to control for the fact that participants might have a stronger approach bias towards food in the evening than they have in the morning (e.g., their self-control might be depleted in the evening; Muraven, Collins, Shiffman, & Paty, 2005). Participant was added as a random factor.

Before the actual analysis was conducted, the independent variables (i.e., hunger, rating, PFS, and hour) were centered and scaled, in order to make the results more easily interpretable. They were centered by subtracting the mean of the variables from each data point of that variable. They were then scaled by dividing these scored by their standard deviation. This ensured that the scores were all in the same range. The centered and scaled variables were used in all subsequent analyses.

To check whether allowing intercepts to vary made a difference to the model, the change in the -2 log-likelihood (-2LL) between the old model (without the random factor) and the new model (with the random factor) was tested. This yielded a highly significant result ($X^2_{Change} = -2949.55$, $df_{Change} = -1$, $p < .05$). Adding the random factor 'participant' (i.e., allowing the intercepts to vary) thus significantly improved our model. Consequently, we can conclude that the participants' baseline reaction times vary significantly.

The following model was used for the linear mixed model regression analysis:

*rt_inverted~response_direction*stimulus_type *hunger*POF +*

*+ response_direction*stimulus_type *hunger*rating +*

*+ response_direction*stimulus_type *hour*

+ (1|participant)

Food approach bias. The analysis yielded a highly significant general food approach bias (i.e., the interaction between stimulus type and response direction), F (1, 10034) = 50.745, $p < .05$. Thus, people were significantly faster to pull pictures of food towards themselves than they were to push them away, in comparison to pictures of objects, $\beta = .191$, t (10034) = 7.124, $p < .05$. Figure 1 depicts this relationship: people tend to approach food faster than they avoid it and this difference is greater for food than for objects.

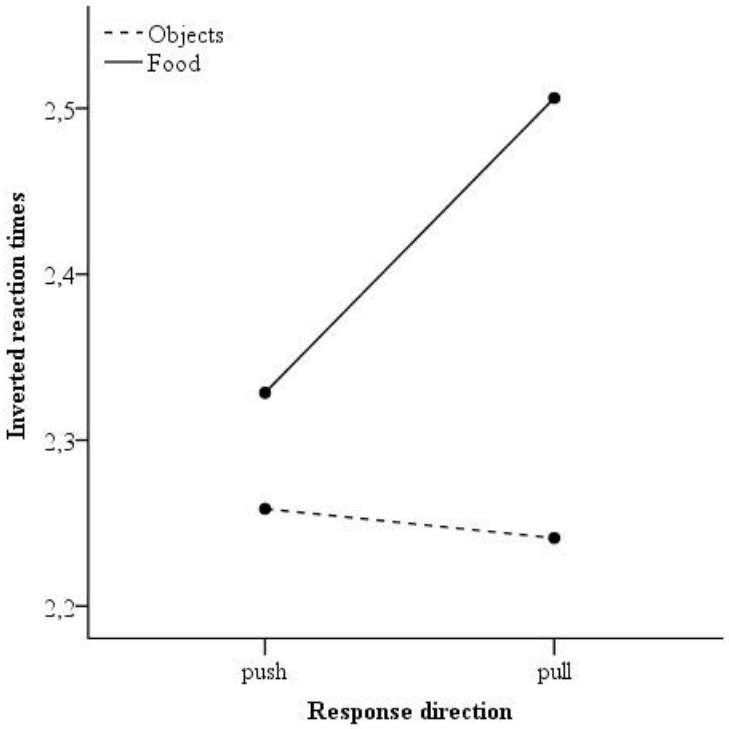

Figure 1. Food approach bias.

Hunger. The analysis also showed a significant interaction effect of stimulus type, response direction and hunger, F (1, 10034) = 5.768, $p < .05$. Hunger thus seems to predict the general approach bias towards food, $\beta = .069$, t (10034.10) = 2.302, $p < .05$. Figure 2 shows the effect of hunger on the approach bias. As can be seen, the hungrier people become,

the greater their food approach bias becomes. We can therefore conclude that hypothesis 1 was confirmed.

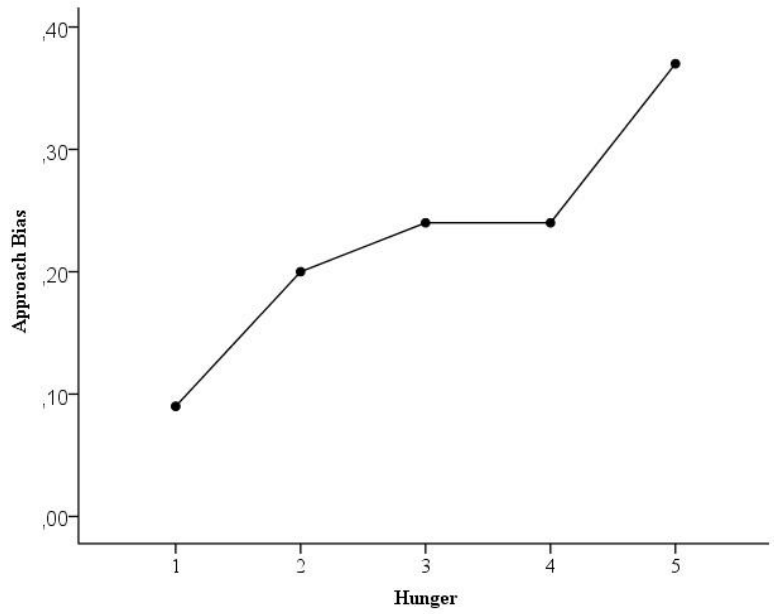

Figure 2. Approach bias as a function of hunger.

Attractiveness. The analysis did not show a significant interaction effect of stimulus type, response direction and rating, F (1, 10034) = .319, p = .572. Thus, approach biases were not influenced by the level of attractiveness of the stimulus. Hypothesis 2 was thus not confirmed.

Hunger-attractiveness interaction. The interaction between response direction, stimulus type, hunger and attractiveness also yielded a non-significant result, F (1, 10034) = 1.187, p = .276. We expected that the relationship between hunger and food approach bias would be stronger for unattractive than for attractive food stimuli. Hypothesis 3 was not confirmed. Because of this unexpected result, the interaction between response direction, hunger and attractiveness was also investigated, in order to analyze whether people's responses to pictures were driven by attractiveness in general; without taking the difference between food and object stimuli into account. Our line of reasoning for this analysis was that

perhaps people are more prone to approach attractive stimuli in general. That is, people might approach an attractive object faster than an unattractive object, just like they approach attractive food stimuli faster than unattractive food stimuli. However, again, this analysis yielded a non-significant result, F (1, 10034) = 1.330, p = .249.

Hunger-Power of Food Scale interaction. The interaction between response direction, stimulus type, hunger and PFS scores yielded another non-significant result, F (1, 10034) = 1.583, p = .208. This means that hypothesis 4, which posed that individuals that were little susceptible to the environment would show a stronger relationship between hunger and approach bias than highly susceptible individuals, was not confirmed.

Discussion

The aim of this research was to investigate whether people exhibit rational approach behaviors towards food (i.e., based on their physical need for food; hunger) or whether they exhibit irrational approach behaviors towards food (i.e., are influenced by stimulus attractiveness and their susceptibility to the food environment). As expected, a general approach bias towards food was found. That is, people were faster to approach food than they were to avoid it, and this effect was stronger for food stimuli than for object stimuli. We also found that the hungrier people become, the stronger this effect becomes (i.e., the faster they are to approach food). Unexpectedly, we did not find an effect of stimulus attractiveness of people's food approach biases, nor did we find an interaction effect between people's hunger and stimulus attractiveness on food approach biases or an interaction effect between people's hunger and susceptibility to the environment on food approach biases.

Limitations

Due to studying participants in the field and trying to limit the invasiveness of the study, certain design decisions had to be made that ultimately might have affected our results.

First, in the current study, attractiveness was measured only once, after all of the other measurements and AAT sessions. This might have influenced our findings. The measurement would have benefitted from a more precise measurement, which could have been established by asking the participants to do the rating task after each AAT session. In the current study, a lot of the food stimuli were foods that people predominantly eat in the evening. A sausage, for example, is perhaps not quite as attractive in the early morning as it is during dinner time. This might have affected the ratings of the participants that rated the pictures in the morning as they will have rated the picture lower in attractiveness than they would have in the evening. When asking participants to rate the same pictures multiple times, more data will be collected and a more thorough understanding of the effects can occur. However, the downside of this design would be that the participants would have to do the same task multiple times, which makes the experiment more invasive. Furthermore, participants might have trouble rating the same picture multiple times as they remember the rating they gave last time and will use that rating as an anchor; ratings will then become dependent on previous ratings, which could change the outcomes.

Secondly, a clearer distinction could be made between attractive and unattractive food stimuli. In the current study, the stimuli came from the food-pics database, which did not measure ‘attractiveness’ (Blechert et al., 2014). We therefore based our attractiveness categorization on a combination of ‘craving’ scores and ‘recognizability’ scores. These two concepts do not fully account for the attractiveness of a stimulus, though. There is a difference between craving and attractiveness, as people might crave foods that they do not find attractive, and attractive foods do not necessarily have to be craved. This difference might have affected the rating scores in the current study.

Thirdly, there are some disadvantages to the mobile method that was used in the current study. Testing people in the field creates a lot of noise that could distort our results.

That is, it is not possible to control for all other factors in the environment when participants have to conduct the experiment in their own environment. There can be certain factors that will influence the participants without the experimenter knowing. For example, participants might have been in a noisy environment where they were constantly distracted (which could distort their reaction times), or participants did not understand the instructions and there was no way of intervening (which could distort general performance). Even though this last example could be investigated via the average error rates, it could still lead to a higher number of participants that would have to be excluded from the analysis. Overall, these issues are general consequences of conducting a field study, and should always be carefully considered and compared to the advantages of the study method.

Lastly, the present study used a small sample of University students with a restricted age range, which limits the generalizability of the findings. Data of only 32 participants was used in the analysis. All participants were students at Leiden University; most of them studying social sciences. Although a mixed models regression analysis was used that accounts for the fact that subjects were drawn from a small population, results would be better substantiated if a bigger and more diverse sample was used.

Future Research

It is important to further investigate the topic of (distorted) food approach behavior and replicate the current study, establishing the validity of the effects found. The current research has identified several factors that could be investigated in potential future research.

First, above-mentioned limitations could be addressed in a replication of this study. That is, the attractiveness ratings could be collected more often. Also, a clearer distinction between ‘attractive’ and ‘unattractive’ could be created (e.g., via a preliminary study), instead of basing this distinction on ‘craving’ and ‘recognizability’ scores. Moreover, a larger and more diverse sample could be used in order to establish the generalizability of the effects.

That is, stronger conclusions could be drawn if a larger sample was used with more diverse participants in terms of age, educational background (i.e., educational level and field of study), and place of residency. Including special populations could also be a valuable addition to this research.

Furthermore, the mobile AAT allows us to not only measure reaction time but also peak accelerations of the approach and avoidance movements (as a proxy of average force put into these movements; Zech, 2015). With this tool, approach biases can be investigated in more detail, which creates new possibilities in the research area of approach-avoidance behavior.

Finally, the current research has taken a first step towards understanding food approach biases in the field and the factors that influence this behavior. However, more factors could be identified. In order to be able to understand and solve the obesity crisis, we need to understand what influences people in their decision to approach food. Examples of factors that could be taken into account are: inhibitory control, calorie content of the food stimuli, gender, or age.

Theoretical Implications

Our first key finding is that a general food approach bias exists. This finding is in line with our expectations and is consistent with earlier studies that found an approach bias towards food in the laboratory (Brignell et al., 2009; Fishbach & Shah, 2006; Loeber et al., 2012; Paslakis et al., 2016). Our second key finding is that people exhibit stronger approach biases towards food when they become hungrier. Hungry people became even faster to approach food than they were to avoid it, in comparison to objects. This finding is completely in line with the findings of Seibt and colleagues (2017), who also found that the hungrier people became, the bigger their approach bias towards food became. Moreover, our finding is a good substantiation of the findings of Nederkoorn and colleagues (2009), who found that

hunger leads to more food intake and purchase. After all, one has to approach something before being able to purchase or eat it. The current research adds to the literature by being one of the first to use the mobile AAT to study the approach-avoidance effect in the food domain. Whereas most research is done in the laboratory, the current study enriches the current literature with new insights from the field.

So far, our research has shown that people exhibit rational approach behaviors towards food: they approach food faster when they are hungry. The current research has also investigated factors that have the potential to elicit irrational approach behaviors towards food. That is, based on the literature, we expected people to show stronger approach biases towards attractive foods than towards unattractive foods. Furthermore, we predicted that the relationship between hunger and approach bias would be stronger for unattractive than for attractive foods. Lastly, we expected people that are more susceptible to the environment would show a weaker relationship between hunger and food approach biases in comparison to people that are less susceptible to the environment. These hypotheses were not confirmed.

It seems that people do not exhibit different approach behaviors towards attractive or towards unattractive food stimuli. This suggests that people might have a general approach bias towards food stimuli and do not automatically differentiate between levels of attractiveness. While this does not completely contradict the current literature, it is a surprising finding as the existing literature seemed to point towards the existence of approach biases towards attractive food stimuli. That is, people tend to attend to attractive and appetitive food stimuli quickly (Brignell et al., 2009), and this attention to palatable foods can contribute to consumption behavior (Kakoschke et al., 2015), for which approach movements are needed. However, most of the existing research, such as studies by Havermans and colleagues (2011) or Nijs and colleagues (2010), did not directly compare attractive and unattractive stimuli. These studies often used attractive stimuli to investigate whether people

were faster to approach these stimuli than they were to avoid them, or they compared the attractive stimuli with objects. The current study adds to the existing literature by directly opposing the two types of food (i.e., attractive and unattractive), as well as comparing these findings with approach behaviors towards objects. Because earlier research had not directly tested people's approach behavior towards unattractive food stimuli, it might be a possibility that people are prone to approach all types of food, no matter the attractiveness. Perhaps this effect was not yet clear due to the lack of unattractive food stimuli in earlier experiments.

We also did not find an interaction effect of hunger and attractiveness on people's approach behavior towards food. This relationship had, to our knowledge, not been investigated before. We based our hypothesis on the findings that people rate food more positively when hungry (Lozano et al., 1999), and that a ceiling effect could limit attractive food stimuli in becoming even more attractive. Following this line of reasoning, we expected to find a stronger relationship between hunger and unattractive food stimuli than between hunger and attractive food stimuli. This line of reasoning was not supported by our results. That is, people exhibited stronger approach biases towards food stimuli when they became hungrier, but this effect did not differ between attractive and unattractive food stimuli. This is not surprising given the fact that there we did not find an effect of attractiveness on food approach bias either. Moreover, our argumentation that more positive evaluations would be related to stronger approach biases might have been flawed. A person's explicit evaluation of food stimuli (i.e., a positivity or, in our case, attractiveness rating) can differ from their implicit evaluation (Czyzewska & Graham, 2007). Approach biases measure automatic/implicit evaluations, but our hypothesis was based on research that measured explicit evaluations. This might explain the incongruence between our expectations and results as well, for both the main effect of attractiveness and the interaction effect of attractiveness and hunger on food approach biases.

We did not find an interaction effect of hunger and susceptibility to the environment either; and also no main effect of susceptibility to the environment. Our hypothesis was based on the idea that people that are more susceptible to their external environments would show a weaker relationship between hunger and food approach biases, because they would be more easily influenced by other factors than their own hunger to approach food. This reasoning was not supported by our results, which is highly surprising given the findings of Zech (2017) and the fact that the PFS has been shown to be a reliable tool to assess the impact of food-rich environments on eating desires without the biological need for food (Lowe et al., 2009). A study by Mitchell, Cushing and Amaro (2016) might give a possible explanation for this discrepancy. In this study, the PFS was used on preadolescents and adolescents and found that the 15-item PFS, developed by Lowe and colleagues (2009), best explains the psychometric properties in youth. In the current research, however, the 21-item PFS was used, while our sample mainly consisted of adolescents. A replication of the current study might therefore benefit from the use of the 15-item PFS as described by Lowe and colleagues (2009). The fact that we did not find a main effect of susceptibility to the environment on food approach bias either, opposes the findings by Liu and colleagues (2016) that exposure to attractive foods increased approach behaviors towards foods. However, their experiment was conducted with mice, which is not directly translatable to human behavior. Moreover, the mice got actual access to palatable foods, meaning that their findings are based on the situational opportunity of food access, in contrast to our results which are based on the personal characteristic of being susceptible to food in the environment.

Practical Implications

Nowadays, many people experience problems with regulating their eating behavior, which has led many people to have developed eating habits that are dangerous for their health. This is especially dangerous in an obesogenic environment with a plenitude of opportunities

to consume food, as the current research has shown that people have a tendency to approach food (in comparison to objects) and this food approach bias becomes stronger when people get hungrier. The results of the current study thus substantiate the well-known saying that people should not be doing groceries while hungry, and even suggests that it is not only the grocery store that should be avoided when hungry, but all food-rich environments.

It would therefore be good for future research to account for the different environments people are in. Research should aim to study as many people as possible and in environments that are as close to their normal ones as possible. The current study has collected our data through an app that participants used on their own mobile phones and in their own environment. This has many advantages. Mobile phones are widely used, relatively low in cost, easy to use, and portable (Konrath, 2014). In 2016, 84.6% of all Dutch citizens above 12 years old had an internet connection via their mobile phone (CBS Statline, 2016). This makes the use of smartphone apps for experimental research relatively time-efficient and easy. It also creates the possibility to reach a broad demographic group, which increases the generalizability of the results and allows to study a diverse group of participants in terms of age, socioeconomic background, and race (Konrath, 2014). The use of the mobile AAT thus creates the opportunity to study a very broad and diverse group of people.

Moreover, we can use the outcomes of mobile AAT experiments to change the structure of our environment, in order to protect ourselves and the future generation from the health issues of obesity. We have shown that people exhibit approach behaviors towards food that become stronger when they get hungrier. We should therefore make it less easy to approach and consume food in our environments; or at least replace the unhealthy foods with healthier options (i.e., make our environment less obesogenic). It would, for example, be an idea to decrease the amount advertisements of foods in our environment, or to decrease the amount of fast-food eateries and stimulate the establishment of healthy eateries. More specific

examples include replacing the chocolate bars at cash registers in super markets with fruits, or replacing fast-food eateries at train stations with healthy eateries. This way, we could limit the impact of our approach behaviors: there should either be nothing to approach or a healthy food option so that the impact for people's health is less severe.

The mobile AAT has not only shown the need for intervention by showing the robustness of the food approach bias, it is also a tool to intervene. That is, it has been shown that it is possible to change unhealthy eating behaviors by reducing the attentional bias people show towards unhealthy food (Kakoschke, Kemps, & Tiggemann, 2014; Kemps, Tiggemann, Elford, 2015; Werthmann, Field, Roefs, Nederkoorn, & Jansen, 2014). It has also been shown that an AAT is an effective tool in changing (unhealthy) behavior in various domains of life, among which that of food behavior (Becker, Jostmann, Wiers, & Holland, 2015; Neimeijer, de Jong, & Roefs, 2015; Kakoschke, Kemps, & Tiggemann, 2017a; Kakoschke, Kemps, & Tiggemann, 2017b), alcohol dependence (Wiers, Gladwin, & Rinck, 2013), and cigarette smoking (Wittekind, Feist, Schneider, Moritz, & Fritzsche, 2015; Machulska, Zlomuzica, Rinck, Assion, & Margraf, 2016). The mobile AAT thus provides us with an opportunity to make a change in this obesogenic world.

Conclusion

The main goal of the current research was to determine whether people exhibit rational approach behaviors towards food (i.e., are influenced by their feelings of hunger), or whether people exhibit distorted approach behaviors towards food (i.e., are influenced by the attractiveness of food stimuli or their susceptibility to the environment). This research has added to the literature on approach-avoidance behavior by studying participants in the field. The study has shown that the approach-avoidance bias people show towards food is a robust effect, which can also be found in people's own environments. Moreover, this effect is heavily influenced by people's level of hunger. The hungrier people become, the stronger

their approach tendency towards food is. The attractiveness of food cues did not yield a significant effect, and neither did the interaction effects of hunger and attractiveness of food stimuli or the interaction effect of hunger and people's susceptibility to the environment. The results of the current research therefore suggest that people do behave rationally when it comes to approaching food, as hunger is a rational reason to approach and eat food. The use of the mobile AAT in the current research is a unique addition to the literature on approach-avoidance behavior and opens the door to other researchers to do the same. Approach biases have to be investigated more thoroughly, since they have the potential to have great effects on people and their health. This study has identified one of the factors (i.e., hunger) that may underlie the obesity crisis we are currently experiencing. By identifying this factor, and hopefully more in the future, we start to understand the psychological basis of the obesity crisis. This knowledge can help us to create appropriate interventions to reduce this problem.

Literature

Becker, D., Jostmann, N. B., Wiers, R. W., & Holland, R. W. (2015). Approach avoidance training in the eating domain: Testing the effectiveness across three single session studies. *Appetite, 85*, 58-65.

Berridge, K. C., Ho, C. Y., Richard, J. M., & DiFeliceantonio, A. G. (2010). The tempted brain eats: pleasure and desire circuits in obesity and eating disorders. *Brain Research, 1350*, 43-64.

Blechert, J., Meule, A., Busch, N. A., & Ohla, K. (2014). Food-pics: an image database for experimental research on eating and appetite. *Frontiers in Psychology, 5*(617), 1-10.

Brignell, C., Griffiths, T., Bradley, B. P., & Mogg, K. (2009). Attentional and approach biases for pictorial food cues: influence of external eating. *Appetite, 52*, 299-306.

Brockmeyer, T., Hahn, C., Reetz, C., Schmidt, U., & Friederich, H-C. (2015). Approach bias and cue reactivity towards food in people with high versus low levels of food craving. *Appetite, 95*, 197-202.

Brown, J. S. (1948). Gradients of approach and avoidance responses and their relation to level of motivation. *Journal of Comparative and Physiological Psychology, 41*(6), 450-465.

CBS Statline (2016). *Internet; toegang, gebruik en faciliteiten*. CBS (Statistics Netherlands). Retrieved on April 28th, 2017, from http://statline.cbs.nl

Chen, M., & Bargh, J. A. (1999). Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus. *Personality and Social Psychology Bulletin, 25*, 215-224.

Czyzewska, M., & Graham, R. (2007). Implicit and explicit attitudes to high- and low-calorie food in females with different BMI status. *Eating Behaviors, 9*, 303-312.

Fishbach, A., & Shah, J. Y. (2006). Self-control in action: implicit dispositions toward goals and away from temptations. *Journal of Personality and Social Psychology, 90*, 820-832.

Havermans, R. C., Giesen, J. C. A. H., Houben, K., & Jansen, A. (2011). Weight, gender, and snack appeal. *Eating Behaviors, 12*, 126-130.

Heatherton, T. D. & Wagner, D. D. (2011). Cognitive neuroscience of self-regulation failure. *Trends in Cognitive Sciences, 15*(3), 132-139.

Kahneman, D. (2003). Maps of bounded rationality: psychology for behavioral economics. *The American Economic Review, 93*(5), 1449-1475.

Kakoschke, N., Kemps, E., & Tiggemann, M. (2014). Attentional bias modification encourages healthy eating. *Eating Behaviors, 15*, 120–124.

Kakoschke, N, Kemps, E., & Tiggemann, N. (2015). Combined effects of cognitive bias for food cues and poor inhibitory control on unhealthy food intake. *Appetite, 87*, 358-364.

Kakoschke, N., Kemps, E., & Tiggemann, M. (2017a). Approach bias modification training and consumption: A review of the literature. *Addictive Behaviors, 64*, 21-28.

Kakoschke, N., Kemps, E., & Tiggemann, M. (2017b). The effect of combined avoidance and control training on implicit food evaluation and choice. *Journal of Behavior Therapy and Experimental Psychiatry, 55*, 99-105.

Kemps, E., Tiggemann, M., Elford, J. (2015). Sustained effects of attentional re-training on chocolate consumption. *Journal of Behavior Therapy and Experimental Psychiatry, 49*, 94–100.

Kemps, E., Tiggemann, M., Martin, R., & Elliott, M. (2013). Implicit approach-avoidance associations for craved food cues. *Journal of Experimental Psychology, 19*(1), 30-8.

Konrath, S. (2014, in press). *Positive technology: Using mobile phones for psychosocial interventions*. In Encyclopedia of Mobile Phone Behavior, Zheng Yan, IGI Global.

Laham, S. M., Kashima, Y., Dix, J., & Wheeler, M. (2015). A meta-analysis of the facilitation of arm flexion and extension movements as a function of stimulus valence. *Cognition and Emotion, 29*(6), 1069-1069.

Liu, S., Globa, A. K., Mills, F., Naef, L., Qiao, M., Bamji, S. X., & Borgland, S. L. (2016). Consumption of palatable food primes food approach behavior by rapidly increasing synaptic density in the VTA. *Proceedings of the National Academy of Sciences of the United States of America, 113*(9), 2520-2525.

Loeber, S., Grosshans, M., Korucuoglu, O., Vollmert, C., Vollstädt-Klein, S., Schneider, S., ... Kiefer, F. (2012). Impairment of inhibitory control in response to food-associated cues and attentional bias of obese participants and normal-weight controls. *International Journal of Obesity, 36*, 1334-1339.

Lowe, M. R., Butryn, M. L., Didie, E. R., Annunziato, R. A., Thomas, J. G., Crerand, C. E., ... Halford, J. (2009). The Power of Food Scale: a new measure of the psychological influence of the food environment. *Appetite, 53*(1), 114-118.

Lozano, I. D., Crites, S. L., & Aikman, S. N. (1999). Changes in food attitudes as a function of hunger. *Appetite, 32*(2), 207-218.

Machulska, A., Zlomuzica, A., Rinck, M., Assion, H. J., & Margraf, J. (2015). Approach bias modification in inpatient psychiatric smokers. *Journal of Psychiatric Research, 76*, 44–51.

Muraven, M., Collins, R. L., Shiffman, S., & Paty, J. A. (2005). Daily fluctuations in self- control demands and alcohol intake. *Psychology of Addictive Behaviors, 19*(2), 140.

National Health and Medical Research Council (2013). *Australian Dietary Guidelines*. Retrieved on June 21, 2017, from: http://www.nhmrc.gov.au/guidelines-publications/n55.

Nederkoorn, C., Guerrieri, R., Havermans, R. C., Roefs, A., & Jansen, A. (2009). The interactive effect of hunger and impulsivity on food intake and purchase in a virtual supermarket. *International Journal of Obesity, 33*, 905-912.

Neimeijer, R. A. M., de Jong, P. J., & Roefs, A. (2015). Automatic approach/avoidance tendencies towards food and the course of anorexia nervosa. *Appetite, 91,* 28-34.

Nijs, I. M. T., Muris, P., Euser, A. S., & Franker, I. H. A. (2010). Differences in attention to food and food intake between overweight/obese and normal-weight females under conditions of hunger and satiety. *Appetite, 54*(2), 243-254.

Paslakis, G., Kühn, S., Schaubschläger, A., Schieber, K., Röder, K., Rauh, E., & Erim, Y. 2016). Explicit and implicit approach vs. avoidance tendencies towards high vs. low calorie food cues in patients with anorexia nervosa and healthy controls. *Appetite, 107*, 171-179.

Phaf, R. H., Mohr, S. E., Rotteveel, M., & Wicherts, J. M. (2014). Approach, avoidance, and affect: a meta-analysis of approach-avoidance tendencies in manual reaction time tasks. *Frontiers in Psychology, 5*, 1-16.

Rinck, M., & Becker, E. S. (2007). Approach and avoidance in fear of spiders. *Journal of Behavior Therapy and Experimental Psychiatry, 38*, 105-120.

Schroeder, P. A., Lohmann, J., Butz, M. V., & Plewnia, C. (2016). Behavioral bias for food reflected in hand movements: a preliminary study with healthy subjects. *Cyberpsychology, Behavior, and Social Networking, 19*(2), 120-126.

Seibt, B., Hafner, M., & Deutsch, R. (2007). Prepared to eat: How immediate affective and motivational responses to food cues are influenced by food deprivation. *European Journal of Social Psychology, 37*, 359-379.

Solarz, A. K. (1960). Latency of instrumental responses as a function of compatibility with the meaning of eliciting verbal signs. *Journal of Experimental Psychology, 59*(4), 239-245.

Swinburn, B., Egger, G., & Raza, F. (1999). Dissecting Obesogenic Environments: The Development and Application of a Framework for Identifying and Prioritizing Environmental Interventions for Obesity. *Preventive Medicine, 29*, 563-570.

Werthmann, J., Field, M., Roefs, A., Nederkoorn, C., & Jansen, A. (2014). Attention bias for chocolate increases chocolate consumption. An attention bias modification study. *Journal of Behavior Therapy and Experimental Psychiatry, 45,* 136–143.

Wiers, R. W., Gladwin, T. E., Hofmann, W., Salemink, E., & Ridderinkhof, K. R. (2013). Cognitive bias modification and cognitive control training in addiction and related psychopathology mechanisms, clinical perspectives, and ways forward. *Clinical Psychological Science, 1*, 192-212.

Wiers, R. W., Gladwin, T. E., Rinck, M. (2013). Should we train alcohol-dependent patients to avoid alcohol? *Frontiers in Psychology, 4*, 33.

Wittekind, C. E., Feist, A., Schneider, B. C., Moritz, S., & Fritzsche, A. (2015). The approach-avoidance task as an online intervention in cigarette smoking: A pilot study. *Journal of Behavior Therapy and Experimental Psychiatry, 46*, 115–120.

World Health Organization (2013). *Obesity and overweight*. Retrieved on June 21, 2017, from: http://www.who.int/mediacentre/factsheets/fs311/en/.

Wright, D. (1976). Student evaluations of teachers of psychology as a function of academic rank. *Teaching of Psychology, 3*(4), 186-187.

Zech, H. (2015). *The mobile approach-avoidance task* (unpublished master's thesis). Leiden University, Leiden, the Netherlands.

Zech, H. (2017). The relationship between hunger and Power of Food Scale scores. Unpublished raw data.

Appendix: Counterbalanced conditions

As described before, participants will be assigned to a condition based on their participant number; a number that will be given to them based on when they download the app. The first person that downloads the app will receive participant number one and will therefore be assigned to the first counterbalanced condition, the second person to download the app will receive participant number two and will be assigned to the second counterbalanced condition, et cetera. There are twenty-four counterbalanced conditions in the current experiment. Table 1 contains a more detailed overview of the counterbalanced conditions. Of the participants in each counterbalanced condition depicted in Table 1, half will first complete the congruent tasks and then the incongruent tasks, while the other half will first complete the incongruent tasks and then the congruent tasks. This leads to a doubling of the amount of counterbalanced conditions depicted in Table 1.

Table 1. *Counterbalanced conditions.*

Condition	**Time**	**Hunger**	**Condition**	**Time**	**Hunger**
1	Breakfast	Hungry	2	Breakfast	Not hungry
	Lunch	Hungry		Lunch	Hungry
	Dinner	Not hungry		Dinner	Not hungry
3	Breakfast	Hungry	4	Breakfast	Not hungry
	Lunch	Not hungry		Lunch	Not hungry
	Dinner	Hungry		Dinner	Hungry
5	Lunch	Hungry	6	Lunch	Hungry
	Dinner	Not hungry		Dinner	Not hungry
	Breakfast	Hungry		Breakfast	Not hungry
7	Lunch	Not hungry	8	Lunch	Not hungry
	Dinner	Hungry		Dinner	Hungry
	Breakfast	Hungry		Breakfast	Not hungry
9	Dinner	Hungry	10	Dinner	Hungry
	Breakfast	Hungry		Breakfast	Not hungry
	Lunch	Not hungry		Lunch	Not hungry
11	Dinner	Not hungry	12	Dinner	Not hungry
	Breakfast	Hungry		Breakfast	Not hungry
	Lunch	Hungry		Lunch	Hungry