Universiteit Leiden

Faculteit der Sociale Wetenschappen

Food for Thought: The Effects of Hunger and Eating Restraint on Approach-Avoidance Tendencies Towards High- and Low-Calorie Foods

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Master thesis proposal Psychology, specialization in Economic and Consumer Psychology
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Date: 17-04-2020
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Abstract

Approach tendencies have been used to explain the overconsumption of food, providing partial explanation for the current obesity crisis. Central to rising obesity rates, is the consumption of high-calorie foods, but somewhat surprisingly, approach tendencies towards calories remains a highly unexplored subject in non-clinical samples. The present study aimed to address this gap in the literature, investigating approach tendencies towards high- and low-calorie food stimuli, as well as assessing the interaction effects of hunger and restrained eating. By utilising the mobile AAT (Zech, 2020), we measured approach tendencies towards food images, categorised as either high or low in caloric density, both before and after meals as a manipulation of hunger. Results revealed no statistical differences between approach tendencies towards high- and low-calorie foods. Similarly, there were no significant differences between hungry and not hungry participants or restrained or not restrained eating participants, when looking at their approach tendencies toward caloric density. These findings were not in line with research in similar veins, yet being one of the first of its kind, the current study adds to a relatively unknown area of approach tendencies. This helps develop our understanding of our automatic responses towards high-calorie foods as well as opens many doors for future research to build upon.

Food for Thought: The Effects of Hunger and Restrained Eating on Approach-avoidance Tendencies Towards High- and Low-calorie Foods

The tendency to approach or avoid certain stimuli can be demonstrated by most people's ease of approaching appetitive stimuli such as a tasty dessert, and their ease of avoiding fearful stimuli such as a spider. But switch it round and they would find it much harder to avoid the dessert and approach the spider (May et al., 2016). Importantly, these approach-avoidance tendencies are not exclusive towards desserts and spiders. They are applicable to much of our day-to-day behaviours and have been described as a crucial factor contributing towards our psychological and physical survival (Elliot, 2006). There are instances though, where these motivations can lead to maladaptive behaviours such as increased alcohol, tobacco, and unhealthy food consumption (Kakoschke et al., 2019). Considering the current worldwide obesity epidemic (James, 2008; Mazer & Morton, 2018), these approach-avoidance tendencies towards unhealthy (i.e. high-caloric) foods could play an important role in public health. Furthermore, there have been suggestions that different circumstances, such as hunger (de-Magistris & Gracia, 2016) and dietary restraining behaviours (Veenstra & de Jong, 2010) can influence approach tendencies towards foods with high, compared to low, caloric density. Caloric density is defined as the number of calories a food contains per 100 grams. If, in fact, people are predisposed to approach foods with a higher caloric density, then this could provide a partial explanation as to why obesity rates are rising. Consequently, understanding the processes behind approach-avoidance tendencies towards food, particularly for high- in comparison to low-calorie foods, may be vital in developing intervention strategies for obesity.

An explanation of these processes can be provided by dual-process models. For example, the Reflective-Impulsive Model (Deutsch & Strack, 2006) proposes that our behaviour is determined by two separate information processing mechanisms. Unlike controlled processing, which involves conscious decision making that is slow and effortful, automatic processing is quick, effortless and implicit, and includes both affective (i.e. attitudes) and motivational (i.e. approaching) responses to relevant stimuli. Whilst both processes have been shown to predict unhealthy eating behaviours, automatic processing has specifically been linked with approach-avoidance tendencies towards food stimuli based on their calorie content (Kakoschke et al., 2015). Furthermore, the direction of these automatic decisions can be explained through theoretical models of emotion (Lang et al., 1990), in which two systems direct automatic decisions based on stimuli valence. The first system, known as the “appetitive motivational circuit”, encourages approaching positively valenced stimuli, whereas the second system, the “defensive motivational system”, encourages avoidance from negatively valenced stimuli (Phaf et al., 2014). Since high-calorie foods have been shown to have significantly greater valence than low-calorie foods (Racine, 2018), it is plausible that individuals may display faster approach tendencies towards foods of high-calorie compared to low-calorie foods.

The possibility of people having stronger approach tendencies towards high-calorie foods, as opposed to low-calorie foods, is supported by the evolutionary perspective. This perspective posits that humans have developed a weight regulation system that, in order to minimise the risk of starvation, encourages weight gain (Stutzer, 2007). Therefore, being able to detect energy dense foods, such as high-calorie foods, and react appropriately and efficiently, would be an advantageous adaptation (Stewart et al., 2011). Consequently, it is plausible that individuals cognitively process foods differently depending on the caloric density. This possibility is further supported through neuropsychological research. By using functional magnetic resonance imaging (fMRI) to view participants' brain functioning, it was revealed that certain brain regions showed greater activation in response to viewing high-calorie foods, compared with low-calorie foods (Killgore et al., 2003). Interestingly, these regions have been shown to be associated with food processing and reward (Frank et al., 2010). These findings have not only been replicated but furthered by showing that individuals in a state of hunger process calorie dense foods differently to low-calorie foods. This was shown through heightened responses in brain regions involved in processes that require approach and avoidance (van Rijn et al., 2015). These observed brain activities do not necessarily translate into differences in behavioural tendencies of approach though, and therefore it is critical that behavioural research must be utilised.

When it comes to behavioural research, it is worth noting that people have been shown to often associate unhealthy foods with being tastier, as explained by the 'unhealthy = tasty intuition' (Raghunathan et al., 2006). This could partially explain the different responses to high- and low-calorie stimuli. Raghunathan et al. (2006) found evidence suggesting that food which is perceived as higher in calories is actually enjoyed more during consumption and that there is a greater preference for it during choice tasks. This implies that despite results not necessarily being a direct effect, caloric density may still be an influential factor in approach tendencies towards food. This, in combination with the quick accessibility to large quantities of food within modern society, could explain over-consumption of calories. Deciphering which factors and circumstances are most influential on approach tendencies towards high-calorie foods, will aid both individuals and intervention strategies in successful behaviour change.

The effect of calories influencing approach-avoidance tendencies has been well researched in clinical samples. Research has shown approach tendencies towards food stimuli in general (Mehl et al., 2018; Kakoschke et al., 2017). But more importantly, in calorie focused research there are suggestions that patients with obesity and binge eating disorder show greater avoidance tendencies towards low-calorie foods (Paslakis et al., 2017). Although, findings in this domain have been mixed. Kemps and Tiggemann (2015) found that obese participants showed an approach tendency towards both high- and low-calorie foods, whereas the control condition did not show such a tendency. An explanation could be the researcher’s use of food words rather than food images. The use of word stimuli delivers weaker motivational effects than using images (Simmons et al., 2005). This suggests that food images should be the preferred choice of stimuli. Importantly, Kemps and Tiggemann emphasised the need for further research including clear separate categories for high- and low-calorie food stimuli. Whilst research on clinical samples is of vital importance, it is not generalisable to the majority of the population, and non-clinical samples must be assessed.

Research on non-clinical samples’ approach-avoidance tendencies towards high- and low-calorie foods is scarce. However, from research focused primarily on comparisons between clinical and healthy participants, some interesting findings can be observed amongst the non-clinical participants. Paslaskis et al (2016), found that healthy participants had slower reaction times towards high-calorie foods and quicker reaction times towards low-calorie foods, independent of direction of motion. Whilst not specifically measuring approach-avoidance tendencies, these findings suggests the possibility of slower processing of high-calorie foods compared with low-calorie foods. On the other hand, Veenstra and de Jong (2010) showed healthy participants to have slightly stronger approach tendencies towards high-fat foods than towards low-fat foods. Despite these contrasting findings, research exploring approach-avoidance tendencies towards high- and low-calorie foods in healthy participants is minimal. It is therefore vital that this effect is investigated in greater detail as this can increase our understanding of eating behaviours and assist attempts to reduce obesity rates. To deepen this knowledge, various factors that may influence these approach-avoidance tendencies must also be considered, with one example being hunger.

Hungers influence on motivational responses towards food has been observed on occasion. Seibt et al. (2007) found that food deprivation positively increased the perceived valence of food cues and resulted in greater approach tendencies towards the food stimuli. Similarly, Staats and Warren (1974) found that food deprivation increased approach tendencies towards food words. Höfling (2008) and Höfling et al. (2009) revealed how food deprived participants showed stronger immediate evaluations of both appealing and unappealing foods than satiated participants showed. This indicates that hunger increases the desire for basic food properties regardless of the attractiveness of the food. Research has also found evidence suggesting that hunger may alter people's attitudes towards calorie content (Lozano et al., 1999). For example, evidence suggests that that hungry participants are more likely to choose and to pay more for unhealthy snacks as opposed to healthy snacks when compared with satiated participants (Read and van Leeuwan, 1998; de-Magistris and Gracia, 2016). Similarly, satiated participants were more likely to choose a fat-free option of fudge as opposed to regular fat options, when compared with hungry participants (Tuorila et al., 2001), demonstrating the increase in preference for high-caloric foods as a result of hunger. It could be that hunger increases the rewarding value of high-calorie foods, a theory supported by Gilhooly et al (2007), who found that energy restricted participants craved high-calorie foods more than twice as much as before. Collectively, these findings suggest the possibility of hunger increasing motivational responses towards food and more importantly, high-caloric foods.

More specifically to the current study, literature exploring approach-avoidance tendencies in relation to huger and calories is limited. McKenna et al. (2016) found that normal-weight individuals displayed an approach tendency towards healthy foods two hours after eating. Interestingly, this tendency reversed when assessed four hours after eating, and an approach tendency towards unhealthy foods emerged. When looking at food properties, people have also been shown to have a clear preference for sweet foods following consumption of savoury foods (Griffioen-Roose et al, 2011). This implies that following a savoury meal, people may have stronger approach tendencies towards sweet foods. This is important as sweet foods are typically, but not always, high in calories. Similarly, Kraus and Piqueras-Fiszman (2016) found that both healthy and obese participants who were allowed to consume a sandwich had quicker approach tendencies towards sweets than participants who were not allowed to consume the sandwich. These findings were assumed by researchers to be an outcome of either boredom or habituation from eating the sandwich, leading to an increased desire to continue eating. An alternative explanation could be explained through sensory specific satiety (Rolls, 1980), in which people’s preference for a specific food decreases following consumption of that same food. This is important, as people typically consume savoury foods during a meal, particularly for lunch and dinner. This could suggest the possibility that actually participants would display quicker approach tendencies towards high-calorie foods, after consuming a meal. Ultimately, research assessing the influence of hunger on approach-avoidance tendencies towards caloric density is limited, particularly in non-clinical samples. Consequently, the current study investigates this in order to fill a gap in the current literature.

Restrained eating (RE) is another factor suggested to influence approach-avoidance tendencies towards high- and low-calorie foods. RE is a name given when people limit their food consumption. The ‘Restraint Theory’ (Herman & Mack, 1975) labels RE as an eating style under cognitive control, reducing sensitivity to internal satiety cues. This can lead to overeating in scenarios where cognitive control is challenged (Johnson et al., 2012). In support of this, evidence has shown that restrained eaters have stronger approach tendencies towards foods, compared with unrestrained eaters (Neimeijer et al., 2017), but interestingly they have also been shown to be quicker at avoiding food stimuli (Fishbach & Shah, 2006). This suggests that dieters show both approach and avoidance tendencies, towards food stimuli, perhaps due to inner conflict. Papies et al. (2009) speculate that the reason for these avoidance tendencies may be due to dieting instigating stronger evaluations of the negative properties of foods, influencing their attitudes and leading to elevated tendencies.

More importantly to the current study, research suggests that RE impacts approach tendencies towards different properties of food. Veenstra and de Jong (2010) found that restrained eaters show a strong tendency towards both low- and high-fat foods, whereas unrestrained eaters only show a strong tendency towards low-fat foods. Similarly, restrained eaters show stronger implicit likings for high-calorie foods, compared with unrestrained eaters (Houben et al., 2010). In line with this, Höfling and Strack (2008) found that restrained eaters displayed positive implicit approach tendencies towards high-calorie foods despite having negative explicit attitudes towards high-calorie foods. This has also been reflected in restrained eaters having shorter reaction times to high-calorie food cues, compared with unrestrained eaters (Meule et al., 2012). Alternatively, Maas et al (2017) found that people who are bothered about their snacking behaviour are slower to avoid both high- and low-calorie foods, compared with control participants. These findings may be the result of dietary restriction leading to a reduction in sensitivity towards the hedonic and motivational values of both high- and low-calorie foods (Racine, 2018). In light of these findings, it is possible that high-calorie foods can lead to conflicting implicit and explicit evaluations for restrained eaters, resulting in weaker approach and avoidance tendencies towards all food stimuli. In general, past research points towards RE increasing approach tendencies for high-calorie foods, yet this remains inconclusive. Consequently, the current research aims to further develop our understanding of the influence RE can have on food approach tendencies.

In order to accurately measure approach-avoidance tendencies, it is crucial to use the appropriate methodology, one of the most commonly used being approach-avoidance tasks (AATs). First developed by Solarz (1960), it was found that participants were quicker to pull a lever towards themselves (approach) when responding to positive words, compared to negative words, that were displayed on cards. Conversely, participants were quicker at pushing the lever away (avoidance) in response to negative words, compared with positive words. A computerised version where words and images appeared on screen for participants to react to with the lever has since been developed, lauded for its flexibility and applicability to almost any kind of stimuli (Gawronski et al., 2011). However, a key limitation of the AAT is its inability to be utilised outside of a laboratory setting. In response to this, Zech (2020) developed a mobile phone version of the AAT, compatible with Android smartphones. This adaptation involves participants either pulling or pushing the mobile phone towards or away from themselves in response to stimuli presented on the phone screen. The recorded reaction times can then be used to calculate approach-avoidance tendencies. This eliminates the need for research being conducted in a laboratory environment, making it easier for researchers to obtain within-participant differences such as hunger by targeting participants at different times or locations.

Current Study

The current study aims to further our understanding of the psychological mechanisms influencing the overconsumption of high-caloric foods. This knowledge may be useful for individuals aiming to reduce their food consumption or be helpful for those creating effective interventions or strategies for reducing obesity. The mobile AAT will be used to investigate automatic approach-avoidance tendencies towards food stimuli. Specifically, it will focus on approach-avoidance tendencies towards high- compared to low-caloric food stimuli. In addition to this, hunger and RE will be included as additional variables. This is because they are both likely to play an important role in approach-avoidance tendencies towards food (Höfling and Strack, 2008), and consequently, it is important to gain a true understanding of their effects. By taking the findings of previous research into account, the following hypotheses were formulated:

Hypothesis 1: There will be a main effect of calories on approach tendencies. More specifically, participants will have an approach tendency towards high-calorie foods, compared with low-calorie foods.

Hypothesis 2: Hungry participants will have stronger approach tendencies towards high-calorie foods, compared to low-calorie foods.

Hypothesis 3: Restrained eaters will have quicker approach tendencies towards high-calories foods, but not for low-calorie foods, compared to unrestrained eaters.

Methods

Participants

Participants were recruited through "*Sona System"* an online recruitment site for Leiden University students, as well as through posts on various social media pages. The inclusion criteria for the current research was that all participants had normal or corrected vision. As the mobile AAT is only available for Android smartphones, all participants needed access to an Android smartphone. Their participation was rewarded with either 8€ or 4 Sona credits.

A total of 75 participants took part in this study. Two participants were removed in the filtering of data process (See section 'Preliminary analysis'), leaving a total of 73 participants. From this, there were 13 males (mean age = 25.61, SD = 3.66) and 60 females (Mean age = 23.93, SD = 5.45).

Research design

The current research had a mixed design. There were two within-participant independent variables: Caloric density of the stimuli (high vs low), and manipulated hunger ratings (before vs after meal). Hunger was manipulated by assessing participants either before or after eating breakfast, lunch, or dinner. The was also one between-participant independent variable: RE scores (high vs low). The dependent variable was the approach or avoidance tendency towards the stimuli. This tendency was defined as the difference between the reaction time (RT) when pushing away and the RT when pulling towards a specific category of stimuli (e.g. high/low-calorie foods, food/objects).

Procedure

Upon being approached to take part in the research, participants were provided with a link, QR code, and search terms to help direct them to the application on the android market. After downloading the mobile app, participants entered the access code provided and gave their informed consent to take part in the research. Participants were then asked questions such as age, height, weight, and gender, before being randomly assigned to one of the counterbalancing conditions (See 'Counterbalancing conditions' section).

The task began by informing participants to schedule in times for each session depending on what session they are instructed to begin with. Following this, participants commenced with the mobile AAT (see section 'The mobile AAT' for a detailed explanation). If participants were required to conduct the AAT after eating, they were instructed to wait 20 minutes before proceeding with the session. This is because research has suggested that it takes approximately 20 minutes for people to reach satiety after eating (Booth et al., 1982). Once a session was completed, participants would have to wait until either before or after the following meal in order to complete the next stage. After completion of the third session, participants were asked to rate the food images on tastiness (non-attractive – attractive). Following this, participants completed the Dutch Eating Behaviour Questionnaire (Van Strein et al., 1986; see section '*The Dutch Eating Behaviour Questionnaire (DEBQ)*), measuring RE. For some attached related studies there were also some additional questionnaires assessing stress, the power of food, and impulsivity. Finally, participants were debriefed and instructed to email the researchers in order to receive their payment or credits.

Instruments

The AAT was adapted so that the entire study could be done on the participants mobile phone (Zech, 2020).

The mobile AAT

Initially, participants received instructions how to complete the AAT. They were instructed to hold their phone perpendicular to their body and make brisk push or pull movements in response to the stimuli displayed on-screen.

Fig. 1 Movements in mobile AAT (Zech, 2015).

Note. Neutral arm position between stimuli (left), during an approach movement (middle), and during an avoidance movement (right).

The mobile AAT consisted of practice blocks and three measured sessions. Each session was divided into two blocks, whereby the block changed midway through the session. The blocks differ by participants being instructed that the direction they must push or pull for food and object images is now the opposite (See ‘Counterbalancing conditions’ below). Additionally, participants completed a practice block prior to each experimental block to ensure they understood the new instructions.

The practice blocks consisted of 16 food and 8 non-food images. Feedback was provided in the form of a checkmark or a cross for correct and incorrect responses respectively. Incorrect trials were repeated. All images were shown on screen for a maximum of two seconds and participants were instructed to react as quickly as possible. If no response was provided within two seconds, an image of an alarm clock appeared on screen before the next image was shown. Following each image, a white screen appeared, giving participants time to return their hands to their original position. Incorrect trials were repeated, to ensure participants understood their instructions.

The following experimental blocks were completed in the same way as the practice blocks, albeit a few differences. In these blocks, participants viewed all 120 of the stimuli. Moreover, participants no longer saw a checkmark, cross, or alarm clock depending on their response. Instead, the AAT immediately moved on to the next image. The first session of each participant was randomly selected to reduce order effects (see section ‘Counterbalancing conditions’ above for a detailed explanation). Depending on which session the participant began with, the whole procedure was completed in either one or two days. Following each session, participants were asked how hungry they were and how many hours it had been since their last meal.

The mobile AAT measured reaction times in milliseconds, as well as the acceleration of the phone which tells us the direction for each movement. From this it was then possible to calculate the force of the movement.

Counterbalancing conditions

To minimise order effects, some counterbalancing measures were taken. This was done by creating three possible orders in which the study can be completed. This order was determined by which meal (breakfast, lunch or dinner) the participant was randomly assigned to for their first session. After completing their first session, the next session followed in the order of which meal comes next. This means that the three possible orders were as follows; breakfast-lunch-dinner, lunch-dinner-breakfast, or dinner-breakfast-lunch. Therefore, the experiment took participants one day to complete if they began with breakfast or two days to complete if they begin with lunch or dinner. Because participants were assessed either before or after dinner, there was a total of 12 possible orders in which the study could be completed (See ‘Appendix A’)

Set of stimuli used in AAT

The set of food images used in the mobile AAT was formed using images from the *food-pics* database (Blechert et al., 2014). The updated database (Blechert et al., 2019) contains 1211 pictures consisting of 896 food images and 315 non-food images, all tested on American and German samples resulting in a large database that is applicable to western countries. It provides robust, normative data on attributes such as palatability, valence, size, complexity etc. Crucially for the current research, the database specifies the caloric density of each food allowing the stimuli to be divided into high- and low-calorie foods. A total of 120 images were extracted from the database (see stimulus selection procedure), consisting of 80 food images and 40 object images. An additional 24 images were extracted for the practice trials, consisting of 16 food and 8 object images.

Stimuli selection procedure. To get the most generalisable results possible for this study, it was important to select a varied sample of food images that can easily be categorised. Every image had a recognisability rating of over 85%. To ensure distinct separate categories for high- and low-calories, images of foods with either low caloric density or high caloric density were chosen. This was done by choosing food images that were within the highest (for high-calorie) and lowest (for low-calorie) 25th percentiles for caloric density. Finally, images were selected based on attractiveness, allowing there to be four distinct food groups categorised as: attractive healthy, unattractive healthy, attractive unhealthy, unattractive unhealthy.

The Dutch Eating Behaviour Questionnaire (DEBQ)

The DEBQ (Van Strien et al., 1986) was used to measure whether participants are high or low on the RE scale. This questionnaire specifically assesses intentions to restrict food intake in an attempt to lose weight, eating less than desired, and purposely eating slimming foods to reduce weight gain. The questionnaire consists of 33 items, however 13 items measure ‘emotional eating’, 10 items measure ‘external eating’, and 10 items measure ‘restrained eating’. Consequently, only the 10 items measuring RE were applicable to the current research. Participants were asked how often they display the behaviour in question, and these were all answered on a five-point scale (1 – never, 2 – seldom, 3 – sometimes, 4 – often, 5 – very often). Higher scores indicate a higher prevalence of RE. Some examples of items from the scale are: “Do you try to eat less at mealtimes than you would like to eat?” and “do you deliberately eat foods that are sliming?”. Van Strein et al. (1986) found this scale to be highly reliable with a Cronbach’s alpha coefficient of .95.

Results

For the data analysis, IBM SPSS Statistics 26 was used, with all alpha levels set at .05. We executed a paired samples t-test, as well as a series of Mixed Methods Repeated Measures ANOVAs as the data contained both within- and between-subject variables. These analyses are advantageous as each participant is primarily compared with themselves, resulting in reduced error variance, leading to greater statistical power. This is particularly useful when measuring approach tendencies because different individuals will have different reaction speeds. A repeated measures ANOVA will control for this, reducing the effect of individual differences.

Assumption Checks

To ensure the data was suitable for analysis, a preliminary analysis was conducted, including filtering the data and assumption checks.

We filtered the data, removing any reaction times <200ms and participants with error rates >20%. This resulted in two participants being removed from the analysis. This was done to minimise the influence of inaccurate data and outliers.

To test the hypotheses, we calculated four approach tendencies from the reactions to: hungry-high calorie (HH), not hungry-high calorie (NHH), hungry-low calorie (HL), and not hungry-low calorie (NHL). These tendencies were calculated using the median reaction times (RT) to both approaching and avoiding food stimuli and the control stimuli and then calculating the difference in score (i.e. approach tendency **=** (RT push food – RT pull food) – (RT push objects – RT pull objects)). A positive value indicates an approach tendency towards food compared to objects, whereas a negative value indicates an avoidance tendency.

From these approach tendencies, we were then able to calculate individual approach tendencies for high calorie (HC), low-calorie (LC), Hungry (H), or not hungry (NH). We calculated this by taking the mean from the two variables that correspond with the desired outcome variable. An example of this is: HC = (HH + NHH) / 2.

To calculate the Restrained eating (RE) score, we took the mean score for each participants DEBQ results. Only participants who answered all 10 of the DEBQ questions had a mean score calculated. This resulted in 58 RE scores (M = 2.73, SD = .91). Higher scores indicate greater signs of RE behaviour.

Assumption checks

Before running the mixed model analysis in SPSS, we screened the data for any violations of normality and for outliers. To check the data was normally distributed we first conducted a Kolmogorov-Smirnov test. This revealed each of the four tendencies to be normally distributed, with all four variables equalling $p = .20$. This was also confirmed when compared with the histograms and Q-Q plots.

To check for outliers, we conducted box plots for each variable**.** These suggested that were outliers for the variables NHH and NHL (see ‘Appendix B’). Consequently, we created scatter graphs comparing the predicted values against the standardised residuals for each variable. There were no values more than ± 2 standard deviations away from the mean. This was also confirmed by the case summaries report. Therefore, there was no need to remove these outliers from the dataset.

The violation of independent errors was resolved by using a mixed ANOVA and as we are using a mixed methods approach, we do not need to check the assumption of sphericity.

Validations

Prior to the main analyses, we conducted a few validation checks. Firstly, we wanted to check if hunger led to quicker approach tendencies towards food in general, regardless of caloric density. To do this we conducted a paired samples t-test, comparing the approach tendencies before (hungry) and after (not hungry) eating. The t-test showed no significant difference between the conditions, $t(57) = -.32$, $p = .75$. This suggests that there was no difference in approach tendencies towards food when hungry compared with when not hungry.

We also wanted to test if RE had an influence on approach tendencies in general. We conducted a one-way ANOVA with the overall approach tendency ((NHH + NHL + HH + HL) / 4) as the dependent measure and RE score as the factor. Results showed that RE did not have a significant influence on approach tendencies towards food, $F(27, 53) = 1.19$, $p = .33$.

Despite these insignificant results, it is still possible for there to be interaction effects between the different variables. We investigated this when testing our hypotheses.

Hypotheses testing

Hypothesis 1

To test if there was a main effect of calories on approach tendencies, we conducted a repeated measures ANOVA to compare the means between the conditions. It was revealed that there was no significant difference between the groups, $F(1,57) = .174$, $p = .68$, indicating that there was no difference in approach tendencies towards foods based on caloric density. As a result, *hypothesis 1* was rejected. The bar chart in Figure 2 shows the visual representation of the ANOVA.

Figure 2

Approach Tendencies for Caloric Density

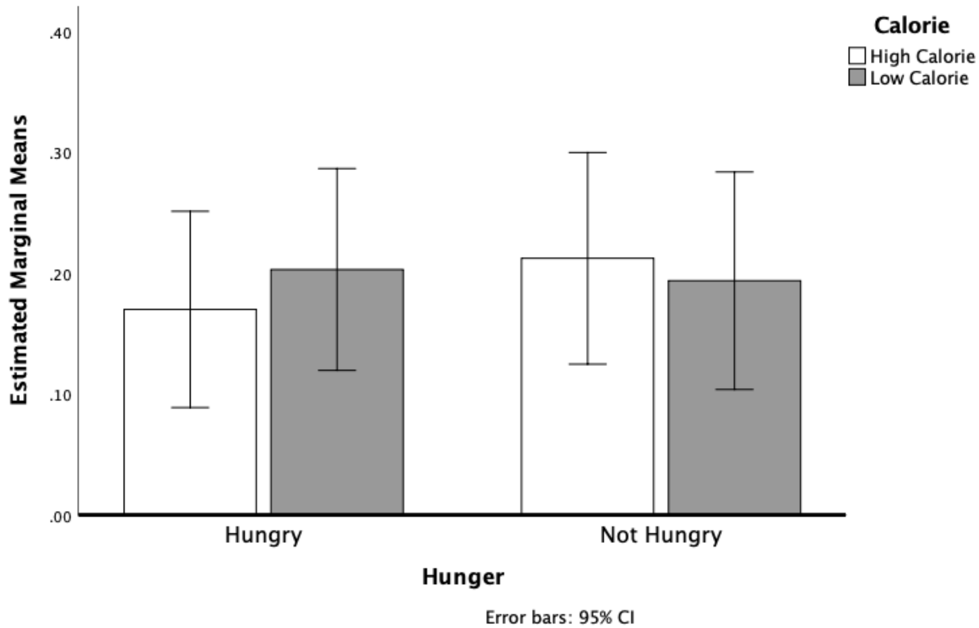
Note. Bar chart comparing the estimated marginal means of approach tendencies (y-axis) for low- and high-calorie stimuli (x-axis; error bars show 95% confidence intervals).

Hypothesis 2

The second hypothesis aimed to see if hunger influences approach tendencies towards high- and low-calorie foods. To test this, we conducted a 2x2 repeated measures ANOVA with calories (high vs low) and hunger (hungry vs not hungry) as within-subject variables. Figure 3 shows a bar chart comparing between the within-subject variables of hunger against calories.

Figure 3

Comparison of Calories and Hunger Approach Tendencies



Note. Bar chart comparing approach tendencies (y-axis) towards high- and low-calorie stimuli for hungry and not hungry participants (x-axis; error bars show 95% confidence intervals).

Results revealed that there was no significant interaction effect between hunger and calories, $F(1, 57) = 3.02$, $p = .09$, suggesting that hunger does not influence approach tendencies towards high- and low-calorie foods. As such, *hypothesis 2* was rejected.

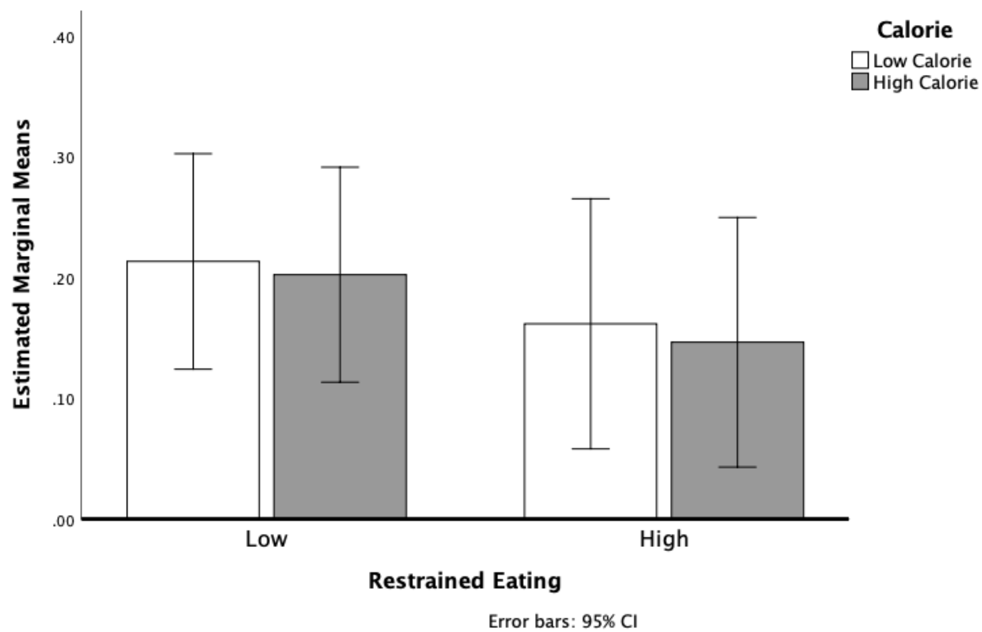
Hypothesis 3

The third hypothesis aimed to see if RE influences approach tendencies towards high- and low-calorie foods. From participants RE scores, we used a mean split to create two groups classified as low-RE and high-RE. Descriptives revealed there were 31 participants in the low-RE group and 23 participants in the high-RE group. It was expected that participants who scored highly on RE would display stronger approach tendencies towards high-calorie foods, but also stronger approach tendencies towards low-calorie foods.

To test the hypothesis, we conducted a two-way repeated measured ANOVA with calories (high vs low) as a within-subjects variable and RE scores (high vs low) as a between-subjects variable. The bar chart in Figure 4 shows the results of the ANOVA.

Figure 4

Restrained Eaters Approach Tendencies Towards Calories



Note. Comparison of estimated marginal means of approach tendencies (y-axis) towards high- and low-calorie stimuli for participants who scored low or high on the RE scale (x-axis; error bars show 95% confidence intervals).

The repeated measures ANOVA revealed that the differences between the approach tendencies were not statistically significant, $F(1, 52) = .67$, $p = .42$. This implies that there is no difference between the approach tendencies for participants who scored low on the RE scale compared with those who scored high on the RE scale for both high- and low-calorie stimuli. Therefore, *hypothesis 3* was rejected.

Discussion

The current study investigated approach tendencies towards caloric density. More specifically, it aimed to investigate whether people had stronger approach tendencies towards high- as opposed to low-calorie food stimuli. In addition to this, it aimed to see if hunger and RE acted as influencing variables. We used the newly developed mobile AAT to explore the literature-based hypotheses. This allowed us to assess participants before and after breakfast, lunch and dinner creating the manipulation of hunger, whilst we used a subscale of the DEBQ to assess RE. Participants reacted to a series of food and object images, having to either pull or push the phone towards themselves depending on the condition. From this we calculated participants approach tendencies towards food, and we were then able to use a mix of t-tests and ANOVAs to analyse the data.

Hypothesis 1 predicted that participants would show stronger approach tendencies towards high-calorie foods compared to low-calorie foods. This hypothesis was not supported as there was no significant difference between conditions. Hypothesis 2 predicted that hungry participants would display stronger approach tendencies towards high-calorie foods as opposed to low-calorie foods. Again, this hypothesis was not supported by the results, where there was no significant difference between the hungry and not hungry conditions. For our third hypothesis, we expected participants who scored highly in RE to display stronger approach tendencies towards high-calorie foods and weaker approach tendencies towards low-calorie foods. Likewise, there was no statistical differences found between conditions for high-calorie approach tendencies. As a result, all three hypotheses were rejected.

Limitations

Within the stimuli selection procedure, the images were selected with great care allowing for clearly defined groups for high- and low-calorie foods, as to not repeat a caveat highlighted in Kemps and Tiggemman's (2015) research. Furthermore, an aspect which sets the current research apart from others is the use of the mobile AAT (Zech, 2020). This enabled the researchers to gather within-subject data outside of laboratory conditions, with participants in their own environment. Consequently, the current research had the advantage of being able to collect data which would otherwise be extremely difficult to collect in a laboratory setting. We were able to measure participants before and after eating for each meal of the day, without having to take participants into an unfamiliar setting for an extended period of time. From this we could easily measure approach tendencies before or after eating, leading to our two conditions of manipulated hunger.

Yet, a limitation of conducting a field experiment is the loss of control over both extraneous variables and the conditions. We were unable to measure the difference in time between eating and the completion of the AAT, making us reliant on participants honesty. In future, it would be useful to include a method of accurately recording when participants ate food and when they began the AAT. This would ensure the hunger manipulation was as effective as possible. Participants were asked to wait 20 minutes after eating before they completed the AAT, ensuring satiation (Booth et al., 1982). But without being able to confirm whether or not participants adhered to these instructions, we cannot be certain if the they reached satiety before completing the AAT. If participants had not followed the instructions, then this may explain why there was no significant differences between the hunger and not hungry conditions approach tendencies.

Another limitation lies in the sample size. We analysed an incomplete sample meaning that the current sample size is far below what was desired and required. This was the result of difficulty collecting participants. A large portion of this was due to the mobile AAT being only accessible on Android smartphones. General feedback from potential participants that were approached was that they were unable to participate due to not having access to an Android smartphone. Making the mobile AAT available on other smartphones would improve this issue. An alternative solution could be to temporarily provide participants with an Android smartphone. This would have led to an increased sample size resulting in greater statistical power.

We did not collect any information regarding the specific types of meals or food quantities which participants consumed. There are many ways that collecting this data could have impacted our analysis or results. One example is that if participants only consumed a small amount of food then it is less likely that they would have reached satiation resulting in their approach tendencies being less influenced. Another example is that by recording what types of foods participants ate, we would be able to control for sensory specific satiety. Rolls (1980) explained how sensory specific satiety can play an important role in food preferences. It was discussed how following the consumption of a specific type of food, a person’s preference for that same type of food was found to decrease. Whilst we aimed to select a varied range of food stimuli, it is possible that participants may have consumed foods which were very different to the foods in our set of stimuli. Without information on what participants consumed, it is impossible to know if sensory specific satiety had an influence on our results and if so, which direction this influence was. Obtaining this data would give our results greater reliability and validity.

Consequently, the current study should be used as a basis for future research to explore the same variables in question. Yet, they should have a more specific focus on between-subject differences such as meal type. In addition, they should obtain data on precisely what food and how much was consumed. From this, researchers could investigate how much of a role sensory specific satiety plays in approach tendencies towards high- and low-calorie foods. This could also be reviewed in combination with hunger and RE to check for interaction effects.

Implications

These results are not in line with suggestions from previous neuropsychological research that suggest a difference between approach tendencies towards high- and low-calorie foods (Killgore et al., 2003). Despite this, the lack of quantity in behavioural studies makes it difficult to compare the current findings with previous research. We can say though, that the results contradict the findings of Veenstra and de Jong (2010) who found participants to have a stronger approach tendency to high-fat foods, compared with low-fat foods. Whilst we assessed approach tendencies based on caloric density as opposed to fat content like Veenstra and de Jong, fat has more than twice as many calories as do proteins and carbohydrates. As such, it can be assumed that high-fat foods would in most cases also contain a high-caloric density. In the current research, we used 80 food images to measure approach tendencies. This starkly contrasts Veenstra and de

Jong who used 10 food images, 5 high-fat and 5 low-fat. On the one hand, this could suggest that perhaps the current research contained too large a selection of stimuli that it became difficult to find an effect. On the other hand, it may suggest that Veenstra and Jong did not use a large enough selection of food images and have therefore reported a type I error. It is unclear what this difference in stimuli size could mean and this could be an important route future research could explore.

These findings are in line with Paslaskis et al (2016), who suggested that individuals actually take longer to respond to high-calorie foods. Despite not being significant, the current findings show signs of a similar trend. As the current findings were retrieved from an incomplete sample, it is possible that with a full sample an effect may have been found. It is worth noting that these previous studies were primarily focused on clinical samples. The current study does not focus on clinical samples, and to the best of our knowledge is the only study focusing specifically on approach tendencies towards caloric density for non-clinical populations. Consequently, this research can be used as a platform from which related research can expand on, further developing our understanding of food approach tendencies.

One of the reasons why it was thought that participants would display stronger approach tendencies towards high-calorie foods compared with low-calorie foods was due to high-calorie foods having a greater positive valence. According to theoretical models of emotion, this valence would lead to greater motivational responses. This was not reflected in the current findings. It may have been that not all the food images used in the current study were perceived as positively by our participants. A reason for this could be that the food-pics database was only tested in Germany and America. The current sample primarily consisted of Dutch participants. It is possible that cultural food differences therefore impacted the findings.

We expected restrained eaters to show stronger approach tendencies towards high-calorie foods. This was not supported by the findings. An explanation provided by Racine (2018), which implies that dietary restriction may reduce the motivational values of food, may be applicable to the current study. This would explain why approach tendencies for participants who scored higher on RE showed weaker approach tendencies towards all food stimuli. Nevertheless, this contradicts the findings of Meule et al. (2012) who found that restrained eaters had quicker reaction times to high-calorie foods compared with low-calorie foods. Yet differences lie in the measurements used by Meule et al. and the current study. Whilst the current study used the DEBQ to measure RE, Meule et al. used a different questionnaire. This questionnaire assessed weight fluctuations, an aspect that is not touched upon in the DEBQ and does not necessarily relate to RE. It is possible that there are differences amongst research as to what the exact measurement of RE should be. It would be useful for researchers to compare the two questionnaires and determine if they do in fact both measure the same variable.

Although the current study found no evidence to suggest differences in approach tendencies towards calories, previous research has suggested that there are differences in motivational responses towards different food properties, such as the fat content (Veenstra and de Jong, 2010). In light of this, it would be useful to see if approach tendencies differ between other properties of food. The food-pics database (Blechert et al., 2014) contains information on the protein, fat and carbohydrate content of each food image per 100 grams. Future research should utilise this data to explore approach tendencies towards these properties. This would greatly enhance the current understanding of food approach tendencies and may be vital in aiding strategies of tackling obesity.

Conclusion

In modern society, we are repeatedly finding ourselves in situations of temptation towards unhealthy foods. Combined with the belief that unhealthy food is tastier and our evolutionary predisposition for the consumption of high-calorie foods, obesity rates have been consistently rising. Consequently, the current study aimed to further our understanding of automatic motivational responses towards high- and low-calorie foods, an area which has previously received little attention. It also aimed to explore the interaction of hunger and RE after researchers previously implied that they may be influential.

The results revealed there to be no significant differences in approach tendencies for any of the variables, contradicting the suggestions of previous research. There are possible explanations for these findings which have been discussed, yet it is indeed possible that caloric density does in fact not play a role in influencing approach tendencies towards food. The current study requires replication with slight adjustments that have previously been discussed. If these findings are supported, it will provide obesity intervention makers and strategists with an updated, developed understanding of how the non-clinical population respond to both high- and low-calorie food cues.

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Appendices

Appendix A

Table A1

The Counterbalancing Conditions for Meal Type and Hunger State

Condition	Meal	Before/After
1	Breakfast	Before
	Lunch	Before
	Dinner	After
2	Breakfast	After
	Lunch	Before
	Dinner	After
3	Breakfast	Before
	Lunch	After
	Dinner	Before
4	Breakfast	After
	Lunch	After
	Dinner	Before
5	Lunch	Before
	Dinner	After
	Breakfast	Before
6	Lunch	Before
	Dinner	After
	Breakfast	After
7	Lunch	After

	Dinner	Before
	Breakfast	Before
8	Lunch	After
	Dinner	Before
	Breakfast	After
9	Dinner	Before
	Breakfast	Before
	Lunch	After
10	Dinner	Before
	Breakfast	After
	Lunch	After
11	Dinner	After
	Breakfast	Before
	Lunch	Before
12	Dinner	After
	Breakfast	After
	Lunch	Before

Appendix B

Box plots showing outliers for variables NHH and NHL