THE ROLE OF ATTENTIONAL BIAS IN EXCESSIVE FOOD CONSUMPTION

BY

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Abstract

New Zealand obesity rates have reached epidemic proportions. Excessive eating not only harms individual health, but also the NZ economy; health-related costs soar with rising obesity rates. The need to understand possible mechanisms driving excessive eating behaviour is now crucial. One cognitive mechanism thought to contribute to excessive eating is an attentional bias towards food stimuli. We propose this bias would be similar to the attentional bias that is consistently shown with emotional stimuli (e.g. erotic and mutilation images). In this thesis I examined attentional biases towards food stimuli and how they relate to both state (hunger) and trait (waist circumference) factors. In Experiment 1, I investigated the existence of a food-related attentional bias and whether this bias is stronger towards high calorie food images, compared to low-calorie and non-food images (household objects). Participants were asked to fast for 2 hours (to promote self-reported hunger) before completing a distraction task. This task has repeatedly shown an attentional bias to high arousal emotional images (erotic and mutilation scenes). On each trial, participants had to determine whether a target letter was a 'K' or an 'N', while ignoring centrally-presented distractors (high calorie, low calorie and household object images). Compared to scrambled images, all image types were similarly distracting. We found no support for the existence of an attentional bias towards food stimuli; nor did we find a significant association between the bias and either state or trait factors. Experiment 2 sought to conceptually replicate Cunningham & Egeth (2018) who found significant support for the existence of a food-related attentional bias. Participants completed a similar task. However, distractor relevance was manipulated by incorporating both central and peripheral distractors, to increase ecological validity. Additionally, participants were asked to fast for longer (4 hours) to increase self-reported hunger. Despite a significant distraction effect (participants were more distracted on distractor present vs. distractor absent trials) and distractor-location effect (participants were more distracted by central vs. peripheral distractors), participants did not exhibit an attentional bias towards food stimuli. Furthermore, no significant associations between the bias and either state or trait factors were found. Thus, food stimuli do not appear to rapidly capture attention the way that emotional stimuli do, at least not in this task. Future research is needed to clarify the role of cognitive mechanisms in excessive eating behaviour.

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Table of Contents

Abstract i
Acknowledgements iii
Table of Contents v
List of Figures vii
List of Tables viii
The Role of Attentional Bias in Excessive Food Consumption 1
The Dual Process Model of Unhealthy Eating 2
Theories of Attention: Exogenous, Endogenous and Emotional Attention 3
Emotional Attention: Positive vs. Negative Valence Stimuli 5
Attentional Biases to Food Stimuli 8
The Role of Hunger 9
Evidence for a Food-Related Attentional Bias 9
Evidence Against a Food-Related Attentional Bias 12
The Distractor Relevance Issue 13
The Current Experiments 16
Experiment 1 19
Method 20
Pre-registration 20
Participants 20
Materials 21
Task Procedure. 24
Measures 26
Procedure and Design 28
Results/Discussion 29
Response Times 30
Accuracy 32
Exploratory Analyses 33
Summary 34
Experiment 2 37
Method 39

Pre-registration 39
Participants 39
Materials 39
Distraction Task 41
Measures 46
Procedure and Design 46
Results/Discussion 47
Behavioural Results 47
Response Times 48
Accuracy 51
Exploratory Analyses 52
Summary 54
General Discussion 56
Behavioural Results 58
Exploratory Results 58
Limitations 62
Future Directions 65
Conclusions 66
References 68
Appendix 79

List of Figures

Figure 1. Example trial images (Intact vs. Scrambled Images). 23

Figure 2. Schematic trial sequence for the distraction task in Experiment 1. 25

Figure 3. Mean distraction by image category and waist circumference group. 31

Figure 4. Mean accuracy by image category and waist circumference group 32

Figure 5. Mean accuracy by image category and image type. 33

Figure 6. Schematic trial sequence for the distraction task in Experiment 2: Central Trials. 42

Figure 7. Schematic trial sequence for the distraction task in Experiment 2: Peripheral Trials. 44

Figure 8. Mean Response time for central and peripheral trials when distractors are both present and absent. 49

Figure 9. Mean distraction level (ms) by image category when distractors are presented centrally and peripherally. 50

List of Tables

Table 1. Mean (SD) Kcal total, valence and arousal ratings for all images (Experiment 1) 22

Table 2. Mean (SD) RTs for the distraction task in Experiment 1 29

Table 3. Mean accuracy scores for the distraction task in Experiment 1 30

Table 4. Correlational results between hunger and image category (Experiment 1) 34

Table 5. Mean (SD) Kcal total, valence and arousal ratings for all images (Experiment 2) 40

Table 6. Mean (SD) RTs for the distraction task in Experiment 2 for both central and peripheral trials 48

Table 7. Mean accuracy scores for the distraction task in Experiment 2 for both central and peripheral trials 52

Table 8. Correlational results between hunger and image category in Experiment 2 for central and peripheral trials 53

Table 9. Correlational results between accuracy and hunger scores for Experiment 2 on both central and peripheral trials 54

The Role of Attentional Bias in Excessive Food Consumption

“Do not dig your grave with your own knife and fork” – *English Proverb.*

Over-indulging on food is at an all-time high. Worldwide obesity rates have almost tripled since 1975 (World Health Organisation, 2018); obesity is now a greater health threat than undernutrition or infection disease (Kopelman, 2000). The obesity epidemic is rife in New Zealand with 1/3 adults and 1/10 children now considered obese (Ministry of Health, 2017). Such high obesity rates have earned New Zealand the title of third fattest nation in the world, only after the USA and Mexico (Ministry of Health, 2017). The “prize” for such a title is an estimated $1,000,000,000 in health costs and lost productivity for the NZ economy (Signal et al., 2017).

Insufficient physical activity and unhealthy eating are the two prominent factors thought to cause excessive body weight (Kakoschke, Kemps & Tiggemann, 2015; World Health Organisation, 2018). Physical activity has significantly decreased due to advanced transportation methods, increased urbanisation and an elevation in the number of sedentary-style work environments (WHO, 2018). On the other hand, unhealthy eating (consumption of energy-rich foods) has significantly increased; people are now gorging more on high calorie foods (WHO, 2018). Increased food-exposure is thought to play a key role in the rise of unhealthy eating.

Nowadays, it is near impossible to walk to work, watch TV, or listen to the radio without being bombarded with food-related content. Unfortunately, it is the high fat/high calorie foods that are excessively over-represented in our environment through advertising (Hoek & Gendall, 2006). On average, children are exposed to 27 advertisements for fast food, confectionary and fizzy drinks daily (Signal et al., 2017).

High exposure to such stimuli may cause a tenacious desire to excessively consume high calorie foods (Hill & Peters, 1998; Lowe & Levine, 2005). Most people find high calorie foods to be rewarding, but overweight and obese individuals find them particularly rewarding and highly palatable (Werthmann et al., 2011). Thus, overweight/obese individuals might be more likely to automatically orient their attention towards high calorie foods, because they are so desirable. Such an attentional bias may also contribute to the maintenance of craving and desire to eat (Werthmann et al., 2011). An attentional bias towards food is said to exist when an individual automatically allocates their attention to food cues in preference to non-food cues (Kakoschke, Kemps & Tiggemann, 2015). Evidently, investigation into the possible cognitive mechanisms (e.g. attentional biases) driving unhealthy eating behaviour is now of paramount concern.

The Dual Process Model of Unhealthy Eating

According to dual process models, eating behaviour arises through automatic and controlled processing systems (Strack & Deutsch, 2004). Automatic processing is implicit and requires little cognitive effort; a rapidly fast process comprising affective and motivational responses to stimuli (Kakoschke, Kemps & Tiggemann, 2015). Controlled processing is slow, effortful and requires decisions to be made based on individual goals (Kakoschke et al., 2015). The Automatic system produces a different signal to the Controlled system. The resulting outcome is determined by the system that produces the strongest signal (Kakoschke et al., 2015).

The dual-process model can be applied to unhealthy eating behaviour. Automatic processing relates to peoples' attitudes and preferences towards unhealthy food and eating in general (affective component). Additionally, automatic processing also encompasses how driven an individual is to approach and/or avoid unhealthy foods (motivation component). Both affective and motivational components of the automatic system work together to encourage the direction of attention (attentional bias) towards food-relevant stimuli in the environment. Controlled processing relates to peoples' personal goals e.g. weight loss and health. Furthermore, controlled processing also encompasses inhibitory control; an individual's ability to consume food in a controlled manner by preventing the impulse to over-eat (Kakoschke et al., 2015). Both systems guide and regulate behaviour. However, it is an imbalance between the two that could prompt unhealthy eating. For example, if the Automatic system (i.e. an attentional bias towards unhealthy food) produces a stronger signal than the controlled system (i.e. deficient inhibitory control), over-eating may occur (Kakoschke et al., 2015).

This research will investigate whether automatic processing of food-related images is heightened in those who are overweight/obese, causing an imbalance between the two systems. A stronger signal from the automatic system may cause an attentional bias towards food. We will seek to investigate the existence of a food-related attentional bias and how such a bias is related to both state (hunger) and trait (waist circumference) factors.

Theories of Attention: Exogenous, Endogenous and Emotional Attention

Attention is a finite resource tasked with the laborious job of selecting the information that should be thoroughly processed and rigorously represented (Pool, Brosch, Delplanque & Sander, 2016). Our sensory systems are continuously flooded with an abundance of information. Thus, it is important to understand how we adapt and deal with such attentional limitations in a multifaceted ever-changing environment

(Posner, 1980). How do we decide what information is important and worthy of further processing, and what can be safely ignored?

There are three sources of influence that affect attentional selection: Exogenous, endogenous, and emotional attention (Brosch, Pourtois, Sander & Vuilleumier, 2011; Compton, 2003; Corbetta & Shulman, 2002; Pool et al., 2016; Posner, Snyder & Davidson, 1980). Exogenous attention is rapid, involuntary and driven by the low-level perceptual properties of a stimulus. A highly salient stimulus (e.g. brightly coloured) will trigger exogenous influences causing one's attention to swiftly orient towards that stimulus, regardless of task-relevance (Theeuwes, 1994).

Endogenous attention is less rapid, voluntary and consciously initiated. Endogenous attention is largely influenced by individual goals (not external processes) and is directed towards stimuli relevant to those goals (Folk, Remington & Johnston, 1992). Whilst exogenous and endogenous sources rely on separate brain networks, they are not mutually exclusive (Egeth & Yantis, 1997). These two systems function similarly; both enhance activity at the sensorial regions responsible for processing salient or goal-relevant stimuli. Simultaneously, these systems will reduce the activity in the sensorial regions responsible for processing competing stimuli (Corbetta & Shulman, 2002).

Emotional attention is also thought to influence attentional selection (Pool et al., 2016). Emotions play a key role in guiding behaviour (Sander, Grandjean & Scherer, 2005). Emotions not only influence cognitive processing (e.g. decision making, memory) but also signal significant events in the environment (Sander et al., 2005). These emotional signals act as cues for whether stimuli should be approached (e.g. appetitive stimuli) or avoided (e.g. aversive stimuli). Individuals typically devote more attentional resources to stimuli that have emotional value compared to non-emotional/neutral stimuli. Studies have shown that people exhibit attentional biases towards emotional stimuli; people respond more rapidly to emotional compared to neutral stimuli (Kranz, 2015; Murphy, 2016; Pourtois, Schettino & Vuilleumier, 2013; Vuilleumier, 2005). An attentional bias towards an emotional stimulus is referred to as emotional attention (Vuilleumier, 2005). Similar to exogenous attention, emotional attention is rapid and involuntary. Emotional attention also shares similarities with endogenous attention; both are dependent on individual affective state and internal factors (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg & van Ijzendoorn, 2007). However, it is thought that all three sources can have an additive influence, working in unison to produce a distinct attentional effect (Brosch et al., 2011).

Emotional Attention: Positive vs. Negative Valence Stimuli

All emotionally charged stimuli have either a positive or negative valence. Positive valence stimuli are rewarding and have high hedonic/appetitive value (Pool et al., 2016). These positive stimuli encourage approach behaviours (individuals seek to interact with these stimuli) as they often elicit positive emotions (Berridge & Kringelbach, 2008; Schultz, 2004). Alternatively, stimuli can possess a negative valence. Negative stimuli are aversive and do not possess any rewarding value (Pool et al., 2016). Due to their threatening functionality, negative stimuli encourage avoidance behaviours (individuals seek to avoid these stimuli) as they often elicit negative emotions (Berridge & Kringelbach, 2008).

Both positive and negative valenced stimuli rapidly capture attention; such rapidity is evolutionarily advantageous (Anderson, Laurent & Yantis, 2012; Pool et al., 2016; Sali, Anderson & Yantis, 2014). Rapidly knowing when to approach or avoid a stimulus facilitates adaptive behaviour and promotes survival (LeDoux, 1996). Attentional biases towards both positive and negative valenced stimuli have consistently been found throughout the literature (Calvo, Gutiérrez-García & del Líbano, 2015; Gupta, Hur & Lavie, 2016; Most, Smith, Cooter, Levy & Zald, 2007; Padmala, Sambuco, Codispoti & Pessoa, 2018; Pool, Sennwald, Delplanque, Brosch & Sander, 2016). However, numerous tasks are often used to detect the presence of an attentional bias.

The dot probe detection task is most commonly used to study attentional biases towards emotional stimuli (Pool et al., 2016; Yiend, 2010). Participants are instructed to detect either the location, orientation, or identity of a target (as fast as possible) that appears in the same place as one of two simultaneous cues presented before the target. One cue is usually neutral, whilst the other is emotional. Participants are faster to detect the target when it appears in the same location as the emotional cue compared to the neutral cue (Yiend, 2010). Whilst the dot-probe task reflects an attentional orienting bias (based on behavioural performance) it is difficult to identify the cause of the bias. The bias may arise due to initial orienting towards the emotional cue. However, it may also arise because of attentional disengagement difficulty that then requires attentional redirection towards the target (Fox, Russo & Dutton, 2002; Posner, 1980).

Visual search tasks are also used to study emotional biases by asking participants to search for a pre-specified target amongst numerous distractors (Pool et al., 2016). Participants are slower to identify a neutral target embedded amongst emotional distractors than to identify an emotional target embedded amongst neutral distractors. Pool et al., (2016) argue that visual search is the most ecologically valid task available to attentional researchers. However, much like the dot-probe task it is difficult to separate initial orienting from disengagement difficulty.

Attentional biases towards both aversive and erotic images (compared to neutral images) have also been obtained using the emotional blink of attention task (Most, Smith, Cooter, Levy & Zald, 2007; Piech et al., 2011). In this task, participants view landscape images that are presented swiftly. Target images are embedded between the presentation of the landscape images. Participants are required to detect and respond to the target image. However, distractor images are presented before the target image and can have either neutral, aversive or erotic content. Usually, if the distractor image is emotional (aversive or erotic), target detection is disrupted due to the occurrence of an "emotional blink". The emotional valence of such images is distracting and hinders participants' ability to focus on the target. Piech et al., (2011) found that both controls and patients (with unilateral amygdala lesions) were significantly more distracted by the emotional images compared to the neutral images (Piech et al., 2011).

Another task has also been used within our own lab to study attentional biases to emotional stimuli, the emotional distraction task. In this task, participants are asked to identify a target letter that is embedded amongst an array of other non-target letters. When the target array is presented, a simultaneous distractor image is also presented (either in the centre of the array, or in the periphery). Distractor images are presented on either a low frequency (e.g. 25%) or high frequency (75%) number of trials. Distractor images are either emotional (positive or negative valence) or neutral (e.g. household items). Grimshaw et al., (2018), Kranz (2015) and Murphy (2016) all found that participants were significantly more distracted, in the 25% condition (but not the 75% condition), by the emotional stimuli (both positive and negative images) compared to the neutral stimuli. These results support the existence of an attentional bias towards emotional images when stimuli appear infrequently. However, the emotional-attention bias can be controlled when stimuli appear frequently. This task therefore allows us to assess automatic attentional biases towards emotional stimuli when distractors are infrequent.

Attentional Biases to Food Stimuli

Throughout the emotional bias/distraction literature, the same stimuli are often used. Many researchers will investigate the existence of an attentional bias towards emotional stimuli using erotica for positive stimuli, and mutilation/threat images for negative stimuli (Grimshaw, Kranz, Carmel, Moody & Devue, 2018; Kranz, 2015; Murphy, 2016; Padmala, Sambuco, Codispoti & Pessoa, 2018; Piech et al., 2011). These stimuli are commonly used because they are high in arousal/intensity, and consistently show rapid, automatic orienting of attention towards emotional content. It is unclear, however, whether the bias extends to other stimuli e.g. Food. Food is similar to both erotica and mutilation in that it is emotional and motivationally relevant to survival (Mogg, Bradley, Hyare & Lee, 1998). People should be highly motivated to attend to food stimuli; a consistent food source is required to promote survival (Seibt, Hafner & Deutsch, 2007). Without a food source, we cannot survive. Thus, it is expected that individuals should be highly motivated to attend to food stimuli within their environment. However, unlike erotica and mutilation stimuli (which are always relevant to survival), food is thought of as being intermittently relevant to survival. When sated, an individual does not require a food source to function effectively (Seibt, Hafner & Deutsch, 2007). Therefore, food might only have motivational relevance when an individual is hungry and requires satiety needs to be met. Whilst this sounds plausible, little research has investigated whether an attentional bias exists towards food stimuli. Furthermore, few researchers have investigated state motivational influences (e.g. hunger) on attentional biases to food. Understanding attentional biases towards food would not only be useful for explaining tendencies to overeat, but also to answer fundamental questions about how motivation affects emotional attention.

The Role of Hunger

The regulation of food intake is thought to be influenced by three different mechanisms (Seibt, Hafner & Deutsch, 2007). Firstly, when an individual is food deprived this produces unpleasant physiological feelings known as 'hunger'. The regulatory behaviour to seek and consume food is driven by the motivation to end those aversive feelings. Consequently, any behaviour that decreases such negative feelings is reinforced (Seibt, Hafner & Deutsch, 2007). Secondly, when an individual is food deprived his/her readiness to perceive food is heightened, as well as their capacity to automatically attend to food. Consequently, this increases the likelihood of food consumption (Seibt, Hafner & Deutsch, 2007). Thirdly, the valence of food is thought to change with the state of hunger. When food-deprived, the valence of food should increase, causing an increase in approach behaviour towards food stimuli (Seibt, Hafner & Deutsch, 2007). These three mechanisms are not mutually exclusive; they operate in parallel in the regulation of food consumption. My research looks to examine these mechanisms by investigating the conditions under which people automatically attend to food. This research seeks to investigate the existence of an attentional bias towards food, and the relationship to state motivational factors (e.g. self-reported hunger).

Evidence for a Food-Related Attentional Bias

Attentional biases arise when people attribute incentive salience to a stimulus (Berridge, 2009). Food stimuli become salient through repeated associations with rewarding experiences. For example, food consumption will often produce pleasant physiological and emotional feelings. These pleasant feelings are often enhanced if the individual was hungry prior to food consumption. Thus, the rewarding experiences associated with eating (and hunger reduction) are thought to increase the likelihood of food capturing attention, heightening feelings of craving, and triggering approach behaviours towards food (Berridge, 2009; Field & Cox, 2008; Field, Munafo' & Franken, 2009; Franken, 2003; Werthmann et al., 2011).

Overweight/obese individuals are thought to have particularly intense attentional biases towards food, as demonstrated by their increased vigilance (compared to healthy-weight individuals) toward food-related stimuli (Castellanos et al., 2009; Nijs, Muris, Euser & Franken, 2010). This bias can also be demonstrated through eye-tracking. Werthmann and colleagues (2011) used eye-tracking during participants' completion of a dot-probe paradigm. Overweight participants (compared to healthy weight participants) directed their initial gaze more towards images of high calorie foods, compared to neutral non-food images. Despite their longer initial gaze durations, overweight participants also showed a significant reduction in their initial fixation durations for food stimuli (Werthmann et al., 2011). This suggests that overweight participants also exhibited a swift attentional shift *away* from food stimuli. This finding is consistent with Nijs et al., (2010) who measured electrophysiological brain activity during a dot-probe task. Nijs and colleagues found that the ERP P300 of overweight participants reflected a reduction in sustained attention towards food stimuli. Evidently, there is mixed evidence to suggest that trait factors (e.g. body weight) relate to attentional biases towards food.

Hungry individuals are also thought to possess strong attentional biases towards food-related stimuli. Food deprivation has been shown to cause stronger attentional biases to food names in a modified version of the dot-probe task, compared to sated participants (Mogg, Bradley, Hyare & Lee, 1998). This bias can also be demonstrated through the stroop task. Channon & Hayward (1990) asked participants to perform a modified stroop task, after 24 hours of food deprivation. In this task, participants were asked to colour-name food and weight-related words that were written in different-coloured inks, compared with non-food related words. Food deprivation caused significant retardation in the colour-naming of food-related words, compared to non-food-deprived participants (Channon & Hayward, 1990). Evidently, food pre-occupation can arise in individuals with no eating disorder history, even under short-term periods of food deprivation (Channon & Hayward, 1990). However, Lavy & Van Den Hout (1993) found mixed support for the existence of a food-related attentional bias using the modified stroop task. After 24 hours of food deprivation, participants exhibited more colour-naming interference for food words (compared to non-deprived participants) than for holiday words (non-urgent positive words e.g. sea). However, when tool words (neutral words e.g. hammer) were used as control stimuli, the attentional bias towards food stimuli disappeared. Lavy & Van Den Hout concluded that attentional biases towards food stimuli do exist, but only under certain conditions.

Whilst trait (body weight) and state (hunger) factors may play a role, they are not essential for the emergence of an attentional bias towards food. Categorisation tasks have been used to show the existence of an attentional bias towards food in healthy, sated participants (Van Dillen, Papies & Hofmann, 2013). In this task, participants must rapidly decide whether a presented picture appeared on the left or right of a screen. Van Dillen & colleagues (2013) conducted three experiments whereby participants completed the categorisation task under various cognitive loads. A concurrent digit span task was used to manipulate cognitive load. Firstly, they found that participants were slower to categorise attractive food pictures, compared to neutral food pictures, when placed under low cognitive load. However, under high cognitive load the effect disappeared; participants responded equally as fast to tempting foods as they did to neutral foods. The authors argue that when cognitive load is high, people cannot assess the hedonic relevance of appetitive food stimuli. Secondly, they found participants were faster to identify hedonic target words when they were preceded by highly appetitive food images compared to neutral food images. However, this effect was only present under low to moderate cognitive load. Lastly, they found participants were faster to categorise energy-dense foods as edible compared to low energy foods, but only when cognitive demands were low. Once again, the effect was completely eliminated under conditions of high cognitive load. Thus, it would appear that an attentional bias towards appetitive food images may only exist when cognitive demands are minimal.

These studies provide some evidence for a food-related attentional bias that interacts with both trait and state factors. However, more research is needed. Ultimately, deprivation of a basic need may motivate selective attention towards need-relevant stimuli, and bias perception towards stimuli that are food-related (Werthmann et al., 2011).

Evidence Against a Food-Related Attentional Bias

There is mixed support for the existence of a food-related attentional bias. Unlike Channon & Hayward (1990), Stewart & Samoluk (1997) failed to find significant disruption to the colour naming of food-related words, in food-deprived participants, using the modified stroop task. Short-term food deprivation did not cause significant attentional biases towards food stimuli. The attentional bias reported by Channon & Hayward (1990) was also challenged by Lavy & Van Den Hout (1993) on several grounds. They argued that Channon & Hayward used a card version of the stroop task which may be more susceptible to inter-stimulus rumination, compared to single word displays in a blocked format. Secondly, Channon & Hayward used food stimuli that were more closely associated in meaning, compared to their control stimuli. This could have increased rumination and thus, colour-naming delays. Thirdly, participants were only assessed once. This may have created between-group differences, influencing the strength of the bias. Lastly, Channon & Hayward never describe how they recorded colour-word naming time.

The Distractor Relevance Issue

There is mixed support for the existence of a food-related attentional bias. Miscellaneous results have likely occurred due to the various tasks that have been used to investigate the bias. For example, colour-naming interference on the modified stroop task could be due to various cognitive mechanisms; the task does not directly measure attentional bias (Mogg, Bradley, Hyare & Lee, 1998). Thus, it is possible for divergent results to transpire. Additionally, studies using distractor stimuli will often opt for methodological designs that render their distractors task-relevant (Castellanos et al., 2009; Channon & Hayward, 1990; Lavy & Van Den Hout, 1993; Mogg, Bradley, Hyare & Lee, 1998; Nijs et al., 2010; Stewart & Samoluk, 1997; Werthmann et al., 2011). For example, distractors are the focus of attention in stroop-like tasks. Alternatively, distractors may share locations or features with the target in visual search tasks, making them task-relevant. This is problematic because task-relevant distractors reduce both ecological and internal validity. Any attentional bias obtained using task-relevant distractors is usually confounded by other processes. Thus, it is difficult to ascertain whether the significant attentional biases towards food stimuli obtained in prior research are in fact true attentional biases. Limited ecological and internal validity makes it difficult to interpret the findings of prior research.

Cunningham & Egeth (2018) performed one of the most ecologically sound experiments in the food-related attentional bias literature. Cunningham & Egeth employed a distraction task that utilised truly task-irrelevant distractors. A total of 18 university students were recruited to take part in their first irrelevant-distractor task. In this task, participants are asked to classify (one at a time) a set of four alphanumeric characters. On a subset of trials, a distractor image is shown in the periphery of the target display. The distractor image can be one of three types: a high calorie food image, a low-calorie food image, or a household object image. The distractor image is irrelevant and requires no response. Task irrelevance is achieved in three ways. Firstly, the distractor images and alphanumeric targets are semantically and perceptually distinct, so the distractors do not share any features with the targets. Secondly, they appear in different locations (targets are central, distractors are peripheral). Lastly, the participant must respond to the first target before the distractor is presented. Thus, the distractor is dynamic whilst the targets are static; the motion properties of the distractors are truly irrelevant to those of the targets.

In Experiment 1, Cunningham & Egeth did not manipulate hunger or ask participants to report their weight. Participants completed the irrelevant distractor task and distractors were presented on a random 50% of trials. The findings of Experiment 1 suggested that participants were significantly more distracted by irrelevant food images compared to non-food images. Additionally, participants' attention was more strongly biased towards images of energy-dense (high calorie) food images compared to low energy food (low calorie) images.

In their second Experiment a further 18 University students were recruited to take part in the same distraction task. However, participants were asked to consume two small chocolate bars prior to completing the task. Despite the significant distraction effects obtained in Experiment 1 (participants were significantly more distracted by the high calorie food compared to the low calorie and non-food images), there were no significant differences in Experiment 2. Consuming 2 small chocolate bars eliminated the attentional bias towards high calorie foods.

In their third and final Experiment, 32 University students were recruited. Participants were randomly assigned to either a snack (2 small chocolate bars) or no-snack condition. The same distraction task was completed; however, the low-calorie distractor images were replaced with emotional face images. Distractors were shown on 33% of trials. The no-snack participants exhibited greater distraction by images of high-calorie foods compared to non-food and emotional face images. In contrast, those who consumed the chocolate did *not* exhibit greater distraction by high calorie foods compared to non-food and emotional face images. Cunningham & Egeth (2018) concluded that participants were significantly more distracted by energy-dense foods compared to low-energy and non-food stimuli. Furthermore, they argue that naturally occurring goal states are very labile, despite the fact that they can be difficult to ignore.

To investigate attentional biases towards food stimuli one must employ a task with good ecological and internal validity. This research will seek to improve the previous methodologies of past research to investigate the existence of a food-related attentional bias.

The Current Experiments

Attentional biases towards emotional stimuli are thoroughly supported throughout the literature (Anderson, Laurent & Yantis, 2012; Kranz, 2015; Murphy, 2016; Pool, Brosch, Delplanque & Sander, 2016; Sali, Anderson & Yantis, 2014). However, it is unclear whether a similar bias exists for other emotional, intermittently relevant stimuli (e.g. food). Few studies have investigated the existence of an attentional bias towards food stimuli and the role of both trait and state factors. Of the studies that have investigated the bias, there is mixed support for its existence. This study will consist of two experiments that explore food-related attentional biases, and how those biases relate to both trait and state factors.

Experiments 1 and 2 utilised the same irrelevant distractor task (adapted from Forster & Lavie, 2008a, 2008b) that has previously been used in our lab to show significant emotional distraction; participants exhibit stronger attentional biases towards emotional stimuli, compared to neutral stimuli (Grimshaw et al., 2018; Walsh et al., 2018). Hungry participants were asked to determine whether a K or an N was present amongst a series of ‘o’s presented briefly at fixation. Simultaneously, distractor images were randomly presented either centrally (Experiments 1 and 2) or peripherally (Experiment 2). Distractors were images of either high calorie food, low calorie food or household objects (non-food).

All images were taken from the Food-Pics database (Blechert, Meule, Busch & Ohla, 2014) which contains 568 food images and 315 non-food images. The Food-pics database was designed with the intention to be used in Western populations for experimental research on appetitive responses, food perception and eating behaviour (Blechert et al., 2014). Distractor images were presented at a low frequency (on 25% of trials) because Grimshaw et al., (2018) found that distractors disrupted performance on the task when they were presented infrequently (on 25% of trials) but not frequently (on 75% of trials). Notably, this paradigm produces much larger distraction by erotic images (65ms) than neutral images (26ms; Walsh et al., 2018). Therefore, it is well suited for assessing attentional biases to food. Distractors were also presented both centrally and peripherally. Peripheral distractors were included to explore the issue of distractor-relevance. This manipulation was carried out to enhance ecological and internal validity. Furthermore, the manipulation sought to improve on methodological weaknesses that exist in studies utilising tasks such as the dot-probe (whereby distractors are task-relevant).

Furthermore, cognitive load was kept low to promote detection of an attentional bias towards food. Under conditions of high cognitive load, food-related attentional biases have been shown to disappear (Van Dillen, Papies & Hofmann, 2013). Additionally, only women participated in both experiments as women engage in over-eating at a higher frequency than men (Kakoschke, Kemps & Tiggemann, 2015). Gender differences also exist in relation to attitudes towards food (Kakoschke et al., 2015). Thus, only women were selected so as to decrease variability in response to food images and increase the possible detection of a food-related bias (should one exist). Lastly, participants were asked to refrain from eating for either 2 hours (Experiment 1) or 4 hours (Experiment 2) to increase self-reported hunger levels. If a food-related bias exists, then it is more likely to emerge under conditions of hunger (Mogg, Bradley, Hyare & Lee, 1998).

Experiments 1 and 2 were both behavioural experiments that investigated whether an attentional bias towards food stimuli exists. Additionally, we sought to determine whether participants exhibit a stronger attentional bias towards more desirable foods (e.g. energy-dense, high calorie foods). Lastly, we examined the role of both trait (waist circumference) and state (self-reported hunger) factors in food-related attentional biases.

Food-related attentional biases may relate to the trait factor of waist circumference. Waist circumference reflects body composition (fat mass in the body). In turn, body composition may relate to how much attention an individual devotes to food stimuli; overweight/obese people consume more food (von Deneen & Liu, 2011), which may result from stronger food-related attentional biases (compared to those who are of healthy weight). No previous research has looked at the relationship between waist circumference and attentional biases towards food images. Waist circumference was chosen over other body-composition measures such as Body Mass Index (BMI), which can be an unreliable measure of an individual's body fat distribution and overall health (Chan, Watts, Barrett, & Burke, 2003; Keys Fidanza, Karvonen, Kimura & Taylor, 2014; Nuttall, 2015). Waist circumference measurement is rapidly gaining support as a better indicator of fat distribution in the abdominal region, and as a better overall health marker (Chan et al., 2003).

Food-related attentional biases may also relate to the state factor of self-reported hunger. Hungry participants (compared to sated participants), are significantly more distracted by food stimuli compared to non-food stimuli (Channon & Hayward, 1990; Mogg, Bradley, Hyare & Lee, 1998; Seibt, Hafner & Deutsch, 2007). Thus, it is possible that hunger relates to how much attention an individual devotes to a food stimulus; hungrier individuals may exhibit stronger food-related attentional biases compared to less hungry individuals. I did not manipulate hunger; rather, I had all participants fast for a minimum period of time. However, participants still varied in both their self-reported hunger and actual period of food-deprivation. I therefore determined whether individual differences in hunger predicted distraction by food images.

The hypotheses were the same for Experiments 1 and 2. Firstly, I hypothesised that if people do exhibit a food-related attentional bias, then participants should show significantly more distraction on the task when images of food are presented compared to non-food images. Additionally, I predicted that participants would show greater attentional biases (more distraction) towards high calorie food images compared to low calorie and non-food images. Lastly, I predicted that both trait (waist circumference) and state (hunger) factors would be positively associated with attentional biases towards food images. Namely, those with larger waist circumferences (compared to smaller waist circumferences) would show significantly more distraction by food images compared to non-food images. Furthermore, hungrier participants (compared to less hungry participants) would show significantly more distraction by food images compared to non-food images.

Experiment 1

Experiment 1 investigated the existence of an attentional bias towards food stimuli. Few studies have explored this effect, and there is mixed support for the existence of such a bias. Experiment 1 utilised a modified version of the irrelevant distractor task used in previous experiments (Walsh, Carmel, Harper & Grimshaw, 2018). The task was modified to detect food-related effects. The goal of Experiment 1 was to determine whether humans automatically orient their attention towards irrelevant food stimuli within their environment, as indicated by impaired performance on a perceptual task

Several predictions were made. We predicted that participants would exhibit a greater attentional bias toward - as indicated by greater distraction by - food images over non-food images. We proposed this bias would be stronger towards high calorie food images compared to low calorie food images. Namely, participants would exhibit greater distraction on the task when shown images of high calorie foods, compared to low calorie and non-food images. Furthermore, participants with larger waists (compared to smaller waists) would display a greater attentional bias toward – as indicated by greater distraction by - food images compared to non-food images. Lastly, hungrier participants (compared to less hungry participants) would display a greater attentional bias toward– as indicated by greater distraction by - food images compared to non-food images.

Method

Pre-registration

This experiment was pre-registered on AsPredicted (Simonsohn, Simmons & Nelson, 2015). All hypotheses, predictions and planned analyses were pre-specified prior to data collection. See https://aspredicted.org/pi7ix.pdf for Experiment 1 Pre-registration. Pre-registration documents for Experiments 1 and 2 can be found in Appendix A.

Participants

Fifty-five women (6 left-handed) ranging from 18-31 years of age (*M* =18.55, *SD* = 1.84) with normal or corrected-to-normal vision were recruited from the undergraduate psychology pool at Victoria University of Wellington. Participants were asked to refrain from food consumption (fast) for a minimum of two hours prior to their participation in the experiment. All participants provided written informed consent prior to participation and received course credit for their involvement. Two participants were excluded because they failed to meet the pre-determined accuracy criterion of 75%, and one participant was excluded because her distraction measure fell 4 SD above the mean. Thus, a total of 52 participants remained in the sample (age $M = 18.56$, $SD = 1.89$). This study was approved by the Human Ethics Committee of the School of Psychology, Victoria University of Wellington (Wellington, New Zealand).

Materials

Picture Stimuli. Picture stimuli used in the distraction task were 72 colour images taken from the Food-pics database (Blechert, Meule, Busch & Ohla, 2014). The Food-pics database was designed to be used in Western populations for experimental research on food perception, eating behaviour and appetitive responses (Blechert et al., 2014). Stimuli depicted 24 high-calorie foods (e.g. cakes), 24 low-calorie foods (e.g. vegetables), and 24 household objects (e.g. chairs). All of the food images were selected based on the total calorie (Kcal) content reported in the Food-pics database. All of the non-food household object images were selected on the basis of belonging to the category of "typical" household objects and were therefore drawn from a coherent semantic category. See Table 1 for Mean and SD image ratings for kcal, valence, and arousal.

The FoodPics database (Blechert, Meule, Busch & Ohla, 2014) obtained valence ratings using a visual analog scale (approximately 8cm long). The extremes of the visual analog scale were labelled from "Very Negative" to "Very Positive". I conducted independent samples t-tests on the valence ratings (obtained from the Food-pics database) for the image sets. Both high, $t(46) = 4.19$, $p < .001$, and low, $t(46) = 4.11$, $p <$

.001, calorie images were rated as more pleasant than household objects. Valence ratings for high and low-calorie images did not differ, *t* (46) = -1.54, *p* = .138.

Table 1

Mean (SD) Kcal total, valence and arousal ratings for the pictures used in the distraction task on both Experimental and practice trials.

Image Type	Kcal Total	Valence	Arousal
Experimental Trials			
High Calorie	2118 (2004)	52.5 (5.1)	36.6 (3.4)
Low Calorie	73 (62)	56.1 (8.9)	29.9 (6.9)
Household Objects	*N/A*	46.5 (7.0)	18.5 (6.1)
Practice Trials			
High Calorie	1564 (1422)	52.2 (8.5)	35.5 (4.9)
Low Calorie	104 (123)	64.8 (3.2)	37.3 (5.6)
Household Objects	*N/A*	41.9 (7.0)	15.4 (4.9)

The FoodPics database (Blechert et al., 2014) obtained arousal ratings using a similar scale. The extremes of the scale were labelled from “Not at all” to “Extremely”. I conducted independent samples t-tests on the arousal ratings (obtained from the Food-pics database) for the image sets. Both high, $t(46) = 13.60$, $p < .001$, and low, $t(46) = 6.45$, $p < .001$, calorie images were rated as more arousing than household objects. Additionally, high calorie images were significantly more arousing than low-calorie images, $t(46) = 3.55$, $p = .002$.

All of the images were also transformed into pixelated “Scrambled” versions of the original image, such that the object in the original image could no longer be identified (See Figure 1 for an example).

Figure 1. Left Image: Intact distractor image presented on 25% of trials. Right Image: Pixelated “Scrambled” version of the image on the left, presented on 75% of trials.

To produce the “Scrambled” images the pictures were divided into 36 x 36 segments that were randomly recombined in PhotoScape v3.4 (PhotoScape, 2008). Both the scrambled images and intact images were deemed to have the same lower level visual properties. Thus, an estimate of distraction (based on image meaning) could be derived by comparing performance on intact vs. scrambled trials.

A total of 144 images were used (72 original “intact” images, 72 pixelated “Scrambled” versions of the original images). On any given block the “scrambled” images were presented on 75% of trials whilst the intact distractor images were presented on 25% of trials. The order of the images was always randomised.

An additional 24 images were taken from the Food-pics database and used for practice trials. One third of the practice trial images were of high calorie foods (8 pictures), one third were of low-calorie foods (8 pictures), and one third were of household objects (8 pictures). All practice trial images were transformed into "scrambled" versions; 48 practice trial images were available for use (24 "intact" distractor images, 24 "scrambled" images). Participants completed 24 practice trials. Thus, these images were randomly selected from the pool of practice trial images and presented to participants. Akin to the experimental trials, 75% of the practice trial images were "scrambled" images whilst 25% were intact distractor images. See Appendix B for a list of all the images used in Experiment 1.

All of the images used in Experiment 1 were matched for contrast and luminance using Matlab SHINE toolbox (Willenbockel et al., 2010) and were edited with GNU Image Manipulation Program software (GIMP, Version 2.10.2). GIMP was used to ensure that all images had the same dimensions (1024 x 768 pixels). All pictures were presented in colour on a white background and were relatively homogenous in terms of their distance from the FoodPics photographer (≈80 cm).

Task Procedure. The distraction task was adapted from Walsh et al., (2018). To begin each trial a central fixation cross (colour: white, time: between 417-833ms) appeared on a black background on the computer screen. Following this a 200ms target display appeared. On 25% of trials this target display included a centrally presented, intact, distractor image (in colour); on the other 75% of trials the central distractor was a "Scrambled" colour image (11° width x 8.26° height). The colour image was bordered by 6 white letters (0.86° × 0.92°); three of the letters were located 0.75° above the horizontal edge of the image. The other three letters were located 0.75° below the horizontal edge of the image. One of these letters was the target letter (either a K or an N). The other five letters were "o"s. See Figure 2 for a visual depiction of the trial procedure.

Figure 2. Schematic trial sequence for the distraction task. Figure is for illustrative purposes only; stimuli are not depicted in actual size or ratio used.

Participants were told to ignore the centrally presented distractor image and to focus on determining whether the target letter was a K or an N. To do this, participants had to press either the “1” or “2” key on their keyboard (counterbalanced across participants).

Participants were told to use their index and middle finger on their dominant hand to execute their key press responses. Participants had a 2000ms response window to make their decision regarding the target letter. This response window began from the onset of the stimulus. Failure to respond was recorded as an error. Following the participants’ responses, a 600ms blank screen (colour: black) appeared, followed by visual feedback (100ms): “correct” (colour: green), “incorrect” (colour: red), or “please respond faster" (colour: white). The "please respond faster" message appeared if participant responses were > 2000ms. A random inter-trial-interval ranging between 207-623ms was utilised. The target letter and the target location were counterbalanced across the trials.

All trials were randomly intermixed such that high calorie, low calorie, household objects and "scrambled" images could appear at any time. The distraction task was completed in 4 blocks (72 trials per block). Participants were given the opportunity to take small breaks between blocks and at the mid-point of each block. In total participants completed 288 trials. Participants were explicitly informed how often intact distractors would be presented before beginning the experiment. All of the distractor images were presented once to participants.

Before beginning the distraction task all participants completed 24 practice trials (25% with intact distractors, 75% with "Scrambles") to familiarise themselves with the task. Participants were told that they should respond as fast as they could without making mistakes.

Measures

Waist Measurement. All participants were asked to measure their own waist circumference (in cm) after they had completed the task. Waist measurement was used as an alternative to BMI (Body Mass Index) as it is a better measure of fat distribution in the abdominal region (Chan et al., 2003). Participants' waist measurements were used to form two groups (based on a median split): a "smaller" and a "larger" waist circumference group. These groups were used to determine whether waist circumference is related to attentional biases towards irrelevant food stimuli. Participants were continually reminded that if they were uncomfortable at any point they did not have to continue with the measurement. No participant refused to take the measurement. Participants were shown how to take the waist measurement by the experimenter (who demonstrated by taking their own waist measurement). Participants were also given a “How to” guide in case they forgot how to obtain the measurement (see Appendix C). Once participants had obtained their own measurement, they were asked to record it on a piece of paper in front of them.

***Subjective Hunger Scale*.** The Subjective Hunger Scale (Epstein, 1961) was used to measure how hungry the participants felt before beginning the distraction task and after completing the distraction task. The Subjective Hunger Scale is a single-item questionnaire that has the respondent rate how hungry they are feeling at the present moment. Participants are asked to select one of 5 possible choices that best represents their current hunger state.

The 5 possible choices are:

1. Not hungry at all (The thought of eating has absolutely no appeal to me at the moment)
2. Slightly hungry (I would eat something very good, but the thought of food, in general, is not appealing at the moment)
3. Fairly hungry (The thought of food is somewhat appealing to me at the moment, and I could enjoy something good)
4. Hungry (The thought of food is appealing at the moment, and even something ordinary would be welcome)
5. Very hungry (I can't wait to eat something; almost anything would taste good)

The Subjective Hunger Scale was administered to determine whether hunger is related to attentional biases towards irrelevant food stimuli. Additional questions were also added to the Subjective Hunger Scale created by Epstein (1961) to capture all aspects of a participant’s hunger level. Participants were asked to report the amount of time that had elapsed since they last ate (to the nearest minute/hour). If participants were unsure, they were told to take a guess. Furthermore, participants were also asked to report whether they had any eating intolerances (e.g. gluten intolerant) or ate a “Non-standard” diet (e.g. Vegetarian/Vegan diet). These additional items were only asked once at the start of the experiment (the first time the Subjective Hunger Scale was administered).

Procedure and Design

The experiment was programmed and run in E-Prime 2.0 (Schneider, Eschman, & Zuccolotto, 2002a, 2002b). The experiment took approximately 40 minutes to complete. Participants first completed the Subjective Hunger Scale and additional hunger questions, followed by the distraction task. Upon completion of the task participants again completed the Subjective Hunger Scale. Following scale completion participants were then asked to measure and record their own waist circumference. Data were collected in groups of up to four participants per session. All participants completed the experiment in their own private cubicle. Dividing walls were used to separate all of the cubicles. The experimental task was completed by participants on Dell Precision T1700 desktop computers with 24” inch AOC monitors. All of the monitors are maintained with a resolution of 1920 by 1080 pixels and a 120 Hz vertical refresh rate. A viewing distance of 57cm was maintained throughout the experiment with the use of adjustable chin rests.

The independent variables within the experiment were Distractor Type: Intact vs. Scrambled, and Image Category: High Calorie food images vs. Low Calorie food images vs. Household Object images. The dependent variable of primary focus was response time (RT). RT was used to determine distraction (Intact Image RTs –

Scrambled Image RTs for images of the same image category). Accuracy was recorded as a secondary dependent variable. However, accuracy levels were expected to be high due to the ease of the task, and are therefore less informative than measures based on response times.

Results/Discussion

Mean response times (RTs) and overall accuracy rates were calculated for each condition (see Table 2 and 3). RTs were only analysed if they were both correct and longer than 200ms to ensure that anticipatory responses were not included. However, no responses were faster than 200ms. The response window during the task was set at 2000 ms. Thus, for RT inclusion there was no upper bound criterion (i.e. there were no slow outliers). Pre-registered criteria required an accuracy level of 60% within each block, and 75% accuracy overall (across all four blocks). Three participants were excluded from analyses for not meeting these requirements.

Table 2

Mean (SD) RTs (ms) for the distraction task by image category and type in Experiment 1.

Condition	Distractor Intact	Distractor Scrambled	Distraction Index (Intact – Scrambled)
Image Category			
High Calorie	690 (83)	665 (74)	24 (50)
Low Calorie	694 (91)	668 (73)	25 (32)
Household Objects	688 (74)	665 (76)	23 (40)

Response Times

For means and standard deviations by image category and image type see Table 2. Response times (RTs) were first used to assess for significant distraction in the task. Mean RTs (ms) were entered into a 3 (image category: high calorie, low calorie, household object images) x 2 (image type: intact, scrambled) x 2 (waist circumference: small, large) mixed ANOVA. For means and standard deviations by image category and image type see Table 2. A significant main effect of image type was found, $F(1, 50) = 7.94$, $p = .007$, $\eta_p^2 = .14$, indicating that participants were significantly more distracted (slower to respond) when presented with intact distractor images ($M = 690$, $SD = 3.12$) compared to “Scrambled” distractor images ($M = 666.34$, $SD = 1.89$). No other significant main effects or interactions were obtained.

Because our pre-registered hypotheses focused on distraction, and not RTs, a secondary analysis was conducted to compare distraction across image types. A distraction index was calculated whereby scrambled image RTs were subtracted from intact image RTs (Intact image RTs – Scrambled image RTs) for images of the same image category. This analysis was used to investigate whether people exhibit a stronger attentional bias towards specific types of food (e.g. high calorie foods).

Mean distraction index scores were entered into a 3 (image category: high calorie, low calorie, household object images) x 2 (waist circumference: small, large) mixed ANOVA. No significant main effects or interactions were found (all $p > .05$). Notably, the hypothesised interaction of waist circumference and image category was not significant, $F(2, 100) = .53$, $p = .59$, $\eta_p^2 = .58$. Thus, both RT and distraction index values show that participants are not exhibiting stronger attentional biases towards high calorie images compared to low calorie and household object images (see Figure 3).

Table 3

Mean (SD) accuracy (%) for the distraction task by image category and type in Experiment 1

Condition	Distractor Intact	Distractor Scrambled	Total Accuracy
Image Category			
High Calorie	0.95 (0.05)	0.96 (0.04)	
Low Calorie	0.96 (0.04)	0.96 (0.04)	
Household Objects	0.97 (0.05)	0.96 (0.04)	
Total Accuracy			0.96 (0.03)

Note. Total Accuracy = the average total accuracy score for all participants across all 4 blocks.

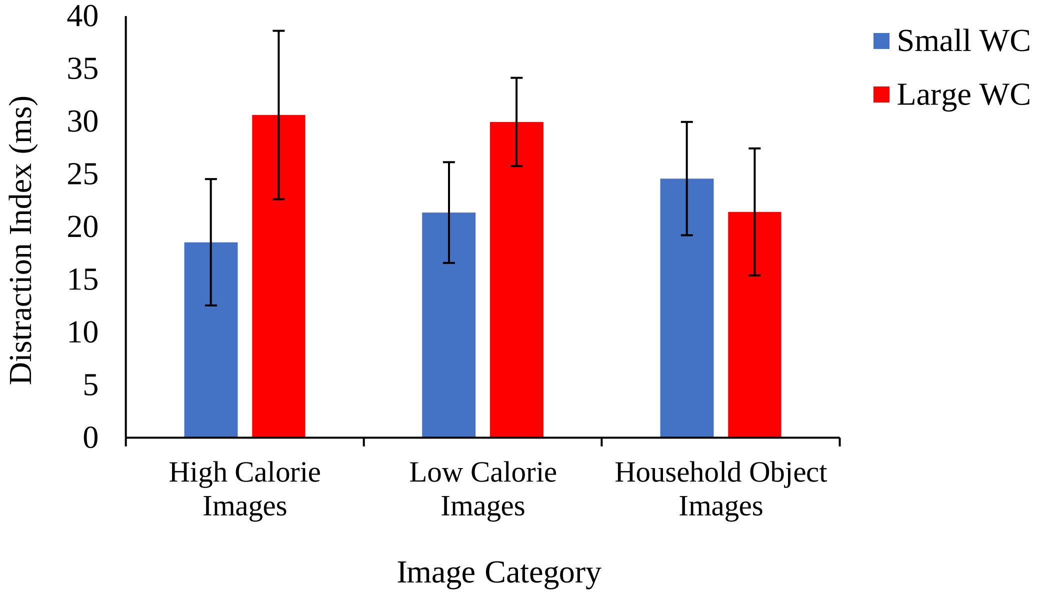

Figure 3. Mean distraction (ms) by image category and waist circumference (WC) group

Accuracy

As anticipated, overall accuracy scores were high (see Table 3). Accuracy scores (%) were entered into a 3 (image category: high calorie, low calorie, household object images) x 2 (image type: intact, scrambled) x 2 (waist circumference: small, large) mixed ANOVA (see Figure 4). For means and standard deviations by image category and image type see Table 3. No significant main effects were found (p >.05). However, a significant interaction between image category and image type was found, $F(1, 50) = 4.17$, $p = .02$, $\eta_p^2 = .08$.

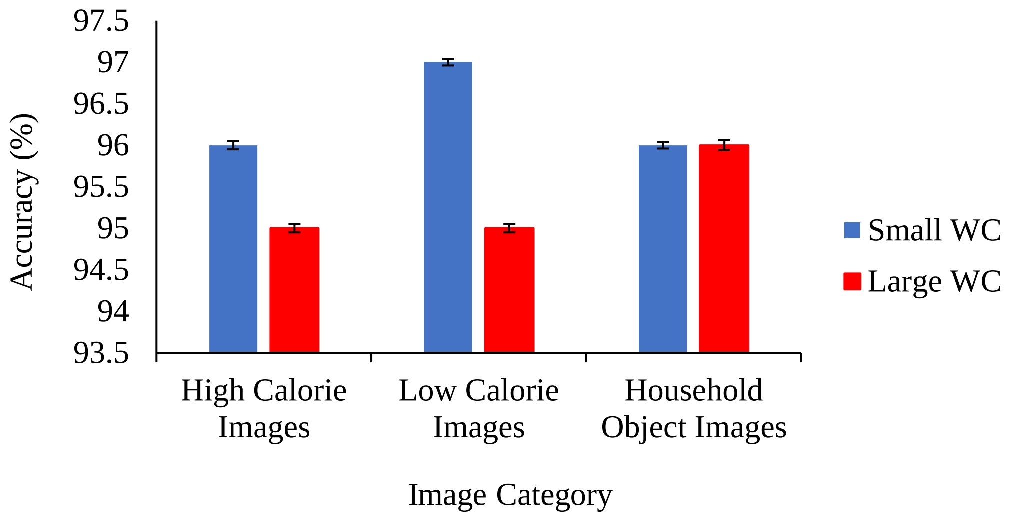

Figure 4. Mean accuracy (%) by image category and waist circumference (WC) group

This interaction suggests that participants' accuracy was reduced when shown intact images of both high (M = .95, SD = .05) and low (M = .95, SD = .04) calorie images compared to scrambled images of high (M = .96, SD = .04) and low (M = .96, SD = .04) calorie foods. Interestingly, accuracy *decreased* when shown scrambled images of household objects (M = .96, SD = .05) compared to intact household objects (M = .97, SD = .05). However, follow-up t-tests were conducted, and no significant results were obtained (all p >.05). Whilst at first glance the high and low-calorie accuracy data supports the possible existence of an attentional bias towards food images (as a function of impaired performance when shown intact images of food stimuli) the differences are not found to be significant in follow-up tests. Thus, the effects should not be over-interpreted (see Figure 5). Furthermore, the reverse pattern of results obtained for the household object images makes it difficult to posit any firm conclusions. Lastly, accuracy was not the dependent variable of primary interest. Thus, this interaction cannot be taken to confirm the existence of an attentional bias towards food. No other significant interactions were found.

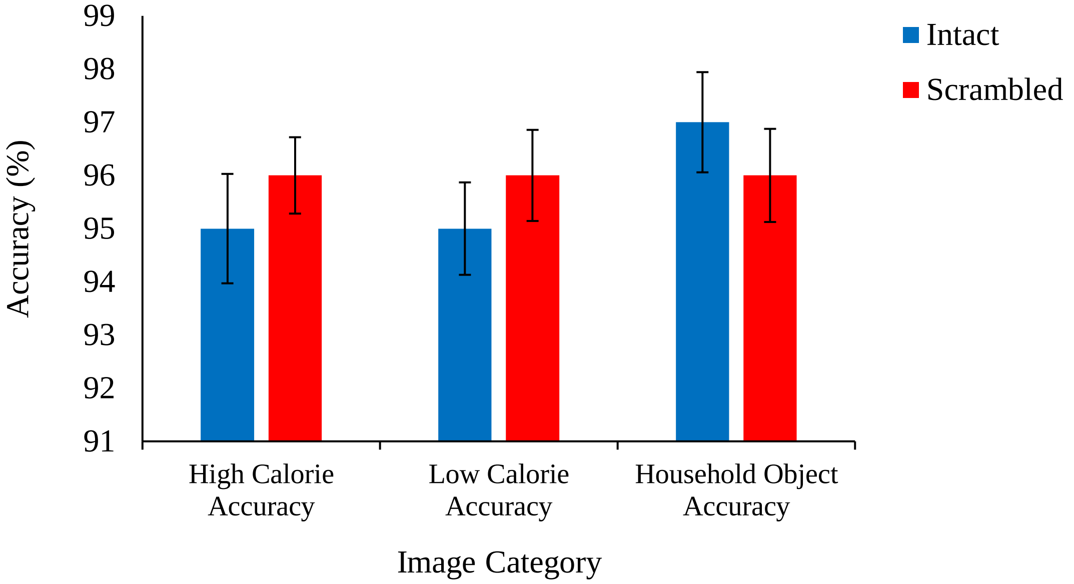

Figure 5. Mean accuracy (%) by image category and image type.

Exploratory Analyses

To ascertain whether hunger significantly influenced level of distraction exploratory analyses were run. Participants were significantly hungrier at Time 2 (*M* =3.04, *SD* = 1.20) compared to Time 1 (*M* = 3.04, *SD* = 1.02), $t(54) = -3.87$, $p < .001$. However, neither hunger at time 1 (start of experiment) nor 2 (post-task) significantly correlated with either high calorie, low calorie or household object distraction (see Table 4).

In sum, these results do not support a relationship between the state factor of hunger and level of distraction. This would suggest that hungrier participants (compared to less hungry participants) were not significantly more distracted by appetitive food images compared to non-food images; Nor, were they significantly more distracted by images of high calorie foods compared to low calorie foods.

Table 4

Correlational results between Hunger (Time 1 and Time 2) and Image Category (High calorie, Low calorie, Household object images) for all Experiment 1 trials

Image Category	Hunger-Time 1	Hunger-Time 2
High Calorie Images	-.04 (*p* = .76)	-.08 (*p* = .57)
Low Calorie Images	.04 (*p* = .81)	-.15 (*p* = .23)
Household Object Images	.04 (*p* = .78)	.17 (*p* = .23)

Summary

Experiment 1 sought to investigate the existence of an attentional bias towards food, akin to the attentional bias seen with highly emotional stimuli (Kranz, 2015; Murphy, 2016; Walsh, Carmel, Harper & Grimshaw, 2018). The RT analyses showed that participants were significantly distracted by the intact images compared to the scrambled images (participants were significantly slower to respond when presented with intact distractors). We predicted that participants would exhibit a stronger attentional bias towards high calorie food images compared to low calorie food images. Additionally, we predicted that this food bias would be related to the trait factor of Waist Circumference. We speculated that participants with larger waists would show a stronger attentional bias towards food images compared to non-food images. However, no significant main effects or interactions were found. Participants did not exhibit stronger attentional biases towards food images over non-food images. Nor did waist circumference relate to the bias; participants with larger waists (compared to those with smaller waists) were not significantly more distracted by food images compared to non-food images.

Furthermore, we predicted that hungrier participants would show a stronger attentional bias towards food images compared to non-food images. However, no significant correlations were found suggesting that hunger does not appear to be a related factor.

Whilst accuracy was not the dependent variable (DV) of primary interest a significant interaction was found. Image type significantly interacted with image category, suggesting that participants were less accurate when shown intact images of food compared to scrambled ones, whilst performing the task. Thus, it is possible participant accuracy was reduced due to greater distraction when shown intact food images. However, follow-up t-tests failed to qualify the interaction. Accuracy was also not the DV of primary interest; whilst these results might indicate increased distraction it is not conclusive evidence for the existence of an attentional bias towards food stimuli.

Although Experiment 1 failed to find significant evidence, an attentional bias towards food may still exist. Methodological weaknesses may have prevented our ability to detect an effect. The Emotional distraction task used in Experiment 1 was an adapted version of the task used by Walsh et al., (2018) in which participants are presented with central distractor images. However, Cunningham & Egeth (2018) found their significant attentional bias towards food using a peripheral distraction task. Whilst central distractor tasks have obtained significant distraction effects with high-arousal emotional stimuli, it is possible that they are not as sensitive as peripheral tasks at detecting food-related effects. One possibility is that because the central distractors are located close to the target, participants are able to make a decision about the target whilst simultaneously viewing the distractor. Thus, the distractor is not task-irrelevant, and people can divide their attention between the two focal stimuli. Beck & Lavie (2005) also argued that central distractors are *never* irrelevant, because individuals always prioritise where they are looking. Experiment 2 will include peripheral distractors to ensure task-irrelevancy of the distractors. In doing so, this will allow us to conceptually replicate Cunningham & Egeth (2018) and determine whether food possesses the power to distract individuals from the task at hand.

Lack of hunger may have also contributed to the absence of a significant attentional bias towards food. University rules/ethics requirements prevented us from having participants fast for longer than two hours. Consequently, few people within our sample were actually hungry. Only 11 (23%) participants rated themselves a “4” (Hungry) on the subjective hunger scale, whilst one person scored themselves a “5” (Very hungry). This is problematic because if a bias does exist it is more likely to emerge under conditions of hunger. Hungry participants have been shown to exhibit greater distraction, compared to sated participants, when presented with food images (Mogg, Bradley, Hyare & Lee, 1998; Piech, Pastorino & Zald, 2011; Seibt, Hafner & Deutsch, 2007). Therefore, it is plausible that the absence of hunger in Experiment 1 is preventing the emergence of an attentional bias towards food stimuli.

Experiment 1 failed to find ample evidence that an attentional bias towards food stimuli exists. However, methodological weaknesses may be preventing detection. Thus, if the issues identified in Experiment 1 are rectified the bias may emerge. Experiment 2 uses both peripheral and central distraction trials to address the potential issue of distractor relevance to target. Furthermore, participants were asked to fast for longer to increase hunger levels.

Experiment 2

Experiment 2 once again sought to investigate the existence of an attentional bias towards food. However, the methodology of Experiment 1 was improved to emulate Cunningham & Egeth (2018) and increase the likelihood of detecting any food-related effects. Cunningham & Egeth (2018) used an irrelevant distractor task adapted from Forster & Lavie (2011). In their task participants are shown a series of matrices, each of which contains four alphanumeric targets. Participants are asked to classify, one at a time, each of the four targets as either a letter or a number by pressing one of two response keys. Simultaneously, distractor images are presented in the periphery of the matrices on a subset of trials. This image is always task-irrelevant and requires no response. Cunningham & Egeth used the same image categories as our first experiment (High calorie food images, low calorie food images and non-food images). Their images were also taken from the FoodPics database (Blechert et al., 2014).

Despite these similarities Cunningham & Egeth presented their distractor images on a higher frequency of trials (50%) compared to Experiment 1 (25%), and only in the periphery of the display. Their participants also completed more trials (600) compared to our first Experiment (288 trials). Additionally, Cunningham & Egeth did not ask participants to fast prior to their task. Nor did they have participants measure/record their own waist circumference. Cunningham & Egeth found that participants were significantly more distracted by images of food compared to non-foods. Additionally, they also found an effect of calorie content; participants were significantly more distracted by images of high calorie foods compared to low calorie foods. Cunningham & Egeth found strong support for the existence of a food-related attentional bias. Thus, we decided to conceptually replicate their work in Experiment 2.

Our second Experiment used a similar task to Experiment 1, modified slightly to more closely resemble that of Cunningham & Egeth (2018). Participants still classified whether a target letter was a K or an N. However, this time they completed a greater number of trials. Additionally, both central and peripheral distractors were included to determine whether distractor location influenced our inability to detect food-related effects in Experiment 1. In some blocks, participants completed a central distraction task, similar to Experiment 1. In other blocks, they completed a peripheral distraction task in which the distractor images were presented in the periphery of the target display. This peripheral version of the task was a conceptual (not direct) replication of the task used by Cunningham & Egeth. The task we chose still allowed us to assess the effects of peripheral distractors. However, we chose this task because of its simplicity and consistent ability to produce greater distraction by peripheral emotional distractors, compared to neutral ones. Experiment 2 also used community participants (not IPRP/University students), allowing us to implement a longer fasting period and boost hunger levels within the sample. Everything else remained the same as in Experiment 1, including the predictions that were made.

Method

Pre-registration

This experiment was pre-registered on AsPredicted (Simonsohn, Simmons & Nelson, 2015). See https://aspredicted.org/k462m.pdf for Experiment 2 Pre-registration. Pre-registration documents for Experiments 1 and 2 can be found in Appendix A.

Participants

Sixty women (9 left-handed) ranging from 18-30 years of age (*M* =22.10, *SD* = 2.25) with normal or corrected-to-normal vision were recruited from in/around the Wellington Community using a range of different advertisements. Recruitment advertisements were placed on Wellington Community Facebook pages. Recruitment fliers were also placed at locations such as Victoria University of Wellington and the Wellington City Library. Participants who expressed interest via Email were contacted, and provided they met all participation criteria were recruited for the study. Participants were asked to refrain from food consumption for a minimum of four hours prior to their participation in the experiment. All participants provided written informed consent prior to participation and received one movie voucher for their involvement in the experiment, as well as light snacks. No participant violated any of the inclusion criteria (e.g. 60% accuracy within a block, 75% accuracy overall) and thus no participants were excluded from analyses. This study was approved by the Human Ethics Committee of the School of Psychology, Victoria University of Wellington (Wellington, New Zealand).

Materials

Picture Stimuli. Picture stimuli were 162 colour images taken from the Food-pics database (Blechert, Meule, Busch & Ohla, 2014). All of the images from

Experiment 1 were used, along with additional FoodPics database images. Stimuli used within this research were 54 high-calorie images (e.g. Chocolate, Ice Cream), 54 low-calorie images (e.g. Lettuce, Grapes) and 54 household object images (e.g. Washing Basket, Lightbulb). Ultimately, a total of 162 images were used in Experiment 2; 18 of which were used for the practice trials. See Appendix D for a list of all the images used in Experiment 2. All of the food images were selected based on the total calorie (Kcal) content reported in the Food-pics database. Participants were never shown the same image more than once. See Table 5 for Mean and SD image ratings.

Table 5

Mean (SD) Kcal total, valence and arousal ratings for the pictures used in the distraction task on both Experimental and practice trials (Experiment 2).

Experimental Trials	Kcal Total	Valence	Arousal
High Calorie	1927.46 (2037.45)	51.53 (5.89)	34.98 (4.12)
Low Calorie	58.50 (62.38)	57.69 (7.71)	31.13 (6.54)
Household Objects	*N/A*	44.79 (6.72)	16.86 (5.46)
Practice Trials			
High Calorie	1501.01 (1003.49)	51.36 (1.20)	33.89 (2.50)
Low Calorie	29.55 (14.05)	60.86 (7.58)	34.50 (9.05)
Household Objects	*N/A*	43.13 (10.57)	18.19 (8.98)

Independent samples t-tests were conducted on the valence ratings (obtained from the Food-pics database) for the image sets. Both high, $t(106) = 5.26$, $p < .001$, and low, $t(106) = 8.98$, $p <.001$ calorie images were rated as more pleasant than household objects. Low calorie image valence ratings were higher than high calorie valence ratings, $t(106) = -5.77$, $p = <.001$.

Independent samples t-tests were also conducted on the arousal ratings (obtained from the Food-pics database) for the image sets. Both high, $t(106) = 19.57$, $p <.001$, and low, $t(106) = 10.90$, $p <.001$ calorie images were rated higher on arousal than household objects. High calorie images were scored higher on arousal than low calorie images, $t(106) = 3.08$, $p = .003$.

Matlab SHINE toolbox (Willenbockel et al., 2010) was used to match all pictures for luminance and contrast. GNU Image Manipulation Program software (GIMP, Version 2.10.2) was used to edit the images to ensure they had the same dimensions (1024 x 768 pixels). All of the images were presented in colour on a white background. All images were relatively homogenous in terms of their distance from the FoodPics photographer (≈80 cm).

Distraction Task

Unlike Experiment 1, “Scrambled” images were not used to calculate distraction in Experiment 2. To conceptually replicate Cunningham & Egeth (2018) distractor absent trials (trials in which no distractors appeared) were used for the baseline condition. On any given block a distractor image was only presented on 25% of trials (distractor present trials) whilst on 75% of trials no distractor image was presented (distractor absent trials). Additionally, image order was randomised. Participants completed 48 practice trials that also maintained this distractor-present (25%) vs. distractor-absent (75%) ratio.

Task Procedure. Central Version. The central version of the distraction task was adapted from Walsh et al., (2018). To begin each trial a central fixation cross (colour: white, time: between 417-833ms) appeared on a black background on the computer screen. Following this, a 200ms target display appeared. On 25% of trials, this target display included a centrally presented colour image: a distractor image (1920px width x 1080px height). The colour image was bordered by 6 white letters (0.86° × 0.92°); three of the letters were located 0.75° above the horizontal edge of the image. The other three letters were located 0.75° below the horizontal edge of the image. One of these letters was the target letter (either a K or an N). The other five letters were lowercase "o"s. On the distractor absent trials, an outline of a rectangle appeared in place of the distractor image (Colour: Black, Line width: 1.5pt). This rectangle was the same size as the distractor image. See Figure 6 for a visual depiction of the trial procedure.

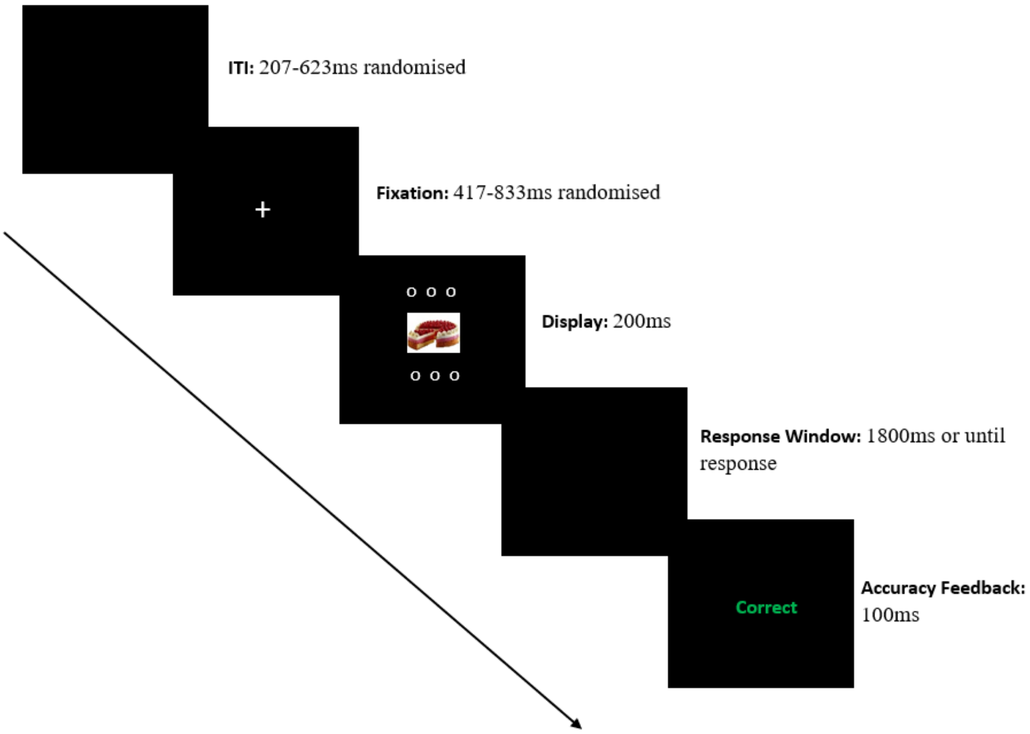

Figure 6. Schematic trial sequence for Experiment 2 central trials. Note. Figure is for illustrative purposes only; stimuli are not depicted in actual size or ratio used.

Participants were told to ignore the centrally presented distractor image and that they should focus on determining whether the target letter was a K or an N. To do this, participants had to press either the “1” or “2” key on their keyboard (counterbalanced across participants). Key response mappings were counterbalanced.

Participants were told to use their index and middle finger on their dominant hand to make their responses. Participants had a 2000ms response window to make their decision regarding the target letter. This response window began from the onset of the stimulus. Failure to respond was recorded as an error. Following the participants’ responses, a 600ms blank screen (colour: black) appeared, followed by visual feedback (100ms): “correct” (colour: green), “incorrect” (colour: red), or “please respond faster” (colour: white**).** This “Please respond faster message appeared if participant responses were >2000ms. A random inter-trial-interval ranging between 207-623ms was used. The target letter and the target location were counterbalanced across the trials. Additionally, trial order was randomised.

Task Procedure. Peripheral Version. The Peripheral version of the distraction task was adapted from Cunningham & Egeth (2018) and Walsh et al., (2018). To begin each trial a central fixation cross (colour: white, time: between 417-833ms) appeared on a black background on the computer screen. Following this, a 100ms target display appeared. On 25% of trials, this target display included a peripherally presented colour image: a distractor image (1920px width x 1080px height). This distractor image could appear either above or below the target letter array (1.90° degrees above or below). The target letter array always appeared in the centre of the screen (at fixation). The target letter array consisted of 6 white letters arranged in a circle (each letter separated by 0.75° degrees). One of these letters was the target letter (either a K or an N). The other five letters were lowercase "o"s. On distractor absent trials, an outline of a rectangle would appear in place of the distractor (Colour: Black, Line width: 1.5pt). This rectangle was the same size as the distractor images. See Figure 7 for a visual depiction of the trial procedure.

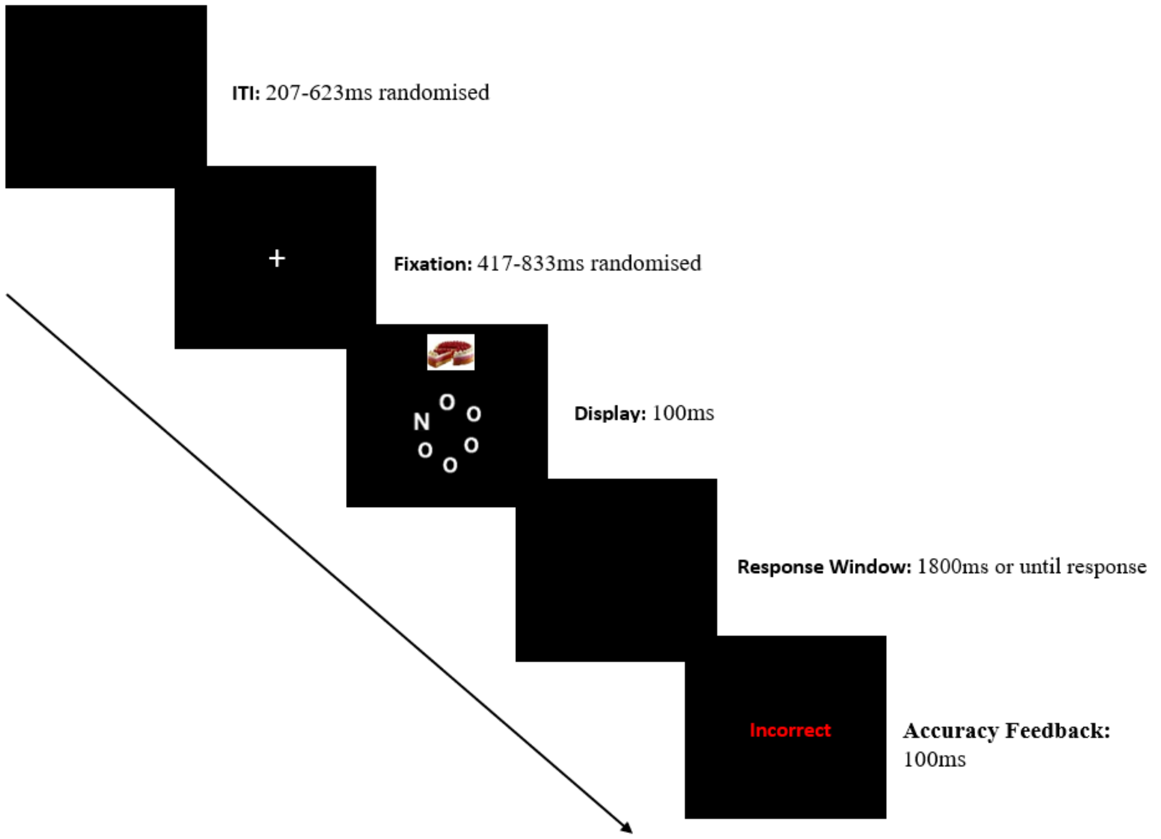

Figure 7. Schematic trial sequence for Experiment 2 peripheral trials. Note. Figure is for illustrative purposes only; stimuli are not depicted in actual size or ratio used.

Participants were told to ignore the peripherally presented distractor images and focus on determining whether the target letter was a K or an N. To do this, participants had to press either the "1" or "2" key on their keyboard (counterbalanced across participants). Key response mappings were counterbalanced such that 50% of participants pressed the '1' key in response to a 'K' target whilst 50% of participants pressed the '2' key in response to a 'K' target.

Participants were told to use their index and middle finger on their dominant hand to execute their key press responses. Participants had a 2000ms response window to make their decision regarding the target letter. This response window began from the onset of the stimulus (anticipatory responses < 200ms were excluded). Failure to respond was recorded as an error. Following the participants' responses, a 600ms blank screen (colour: black) appeared, followed by visual feedback (100ms): "correct" (colour: green), "incorrect" (colour: red), or "please respond faster" (colour: white). This "please respond faster" message appeared if participant responses were > 2000ms). A random inter-trial-interval ranging between 207-623ms was utilised. The target letter and the target location were counterbalanced across the trials. Additionally, the order of the trials was randomised.

The distraction task was completed in 8 blocks (72 trials per block). Four of the blocks were Central distractor trials (the distractor image appeared in the centre of the screen: 288 Central trials in total). The other four blocks were Peripheral distractor trials (the distractor image appeared in the periphery of the screen: 288 Peripheral trials in total). The order of the blocks was counterbalanced such that half of participants completed the blocks in a CCPPCCPP (C: Central, P: Peripheral) order, whilst the other half a PPCCPPCC order. Participants were given the opportunity to take small breaks between the blocks and at the mid-point of each block. A total of 576 trials were completed. Participants were explicitly informed how often distractors would be presented before beginning the experiment. All of the distractor images were shown once centrally, and once peripherally to participants.

All participants completed 48 (24 Central, 24 Peripheral) practice trials before beginning the actual task. The practice trials took place before participants began the appropriate block. For example, if participants completed the central practice trials first, they would then complete 2 whole blocks of central trials. Following this, they would then complete the peripheral practice trials followed by the peripheral blocks. Participants were told to respond as fast as possible without making mistakes.

Measures

Waist Measurement. All participants were asked to measure and record their own waist circumference (in cm) after they had completed the distraction task (the same as in Experiment 1).

Subjective Hunger Scale. The Subjective Hunger Scale (Epstein, 1961) was once again used to measure how hungry the participants felt before beginning the distraction task and after completing the distraction task (the same as in Experiment 1).

Procedure and Design

The experiment was programmed and run in E-Prime 2.0 (Schneider, Eschman, & Zuccolotto, 2002a, 2002b). The experiment took approximately 60-70 minutes to complete. Upon entering the lab, participants first completed the Subjective Hunger Scale and additional questions, followed by the distraction task. Following this, participants were then asked to complete the Subjective Hunger Scale again. Participants were then shown how to measure and record their own waist circumference. Once completed, all participants were debriefed and provided with some light snacks. Data were collected in groups of up to four participants per session. The experiment was completed by the participants in their own private cubicle to ensure privacy/confidentiality. Dividing walls were used to separate all of the cubicles. The experimental task was completed by participants on Dell Precision T1700 desktop computers with 24” inch AOC monitors. All of the monitors are maintained with a resolution of 1920 by 1080 pixels and a 120 Hz vertical refresh rate. A viewing distance of 57cm was maintained throughout the experiment with the use of adjustable chin rests.

The independent variables were Distractor Presence: Distractor Present vs. Distractor Absent, Image Category: High Calorie food images vs. Low Calorie food images vs. Household Object images. The dependent variable of primary interest was response time (RT). RT was used to determine distraction (Distractor absent – Distractor present Image RTs for images of the same image category). Accuracy was recorded as a secondary variable, but accuracy levels were expected to be high due to task ease.

Results/Discussion

Behavioural Results

Pre-registered analysis required that any trial with an RT less than 200ms be excluded, to eliminate trials in which anticipatory responding likely occurred. No trials violated this criterion. Additional exclusion criteria required that participants maintain an accuracy level of 60% within each block and 75% accuracy overall (across all eight blocks). No participants violated these criteria. Mean RTs and accuracy rates were calculated for each condition (See Table 6).

Table 6

Mean (SD) RTs (ms) and distractor indices for both central and peripheral versions of the distraction task, by image category and distractor presence in Experiment 2.

Condition	Response Time	Distraction Index
Central Distractors		
Distractor Absent	618 (88)	
High Calorie Images	664 (109)	46 (52)
Low Calorie Images	660 (100)	42 (36)
Household Object Images	670 (111)	52 (47)
Peripheral Distractors		
Distractor Absent	560 (86)	
High Calorie Images	589 (101)	29 (35)
Low Calorie Images	592 (111)	32 (39)
Household Object Images	596 (86)	36 (43)

Response Times

Firstly, both central and peripheral trial RTs were entered into a 2 (distractor location: central, peripheral) x 4 (image category: high calorie images, low calorie images, household object images, no images) x 2 (waist category: large, small) mixed measures ANOVA. A significant main effect of location was found, $F(1, 58) = 127.66$, $p < .001$, $\eta_p 2 = .69$. Participants were significantly slower to respond when the distractor images were presented in the centre ($M = 665.07$, $SD = 106.10$) compared to in the periphery ($M = 580.50$, $SD = 100.15$) of the target array (See Figure 8). A significant main effect of image category was also found $F(1, 58) = 43.85$, $p <.001$, $\eta_p 2 = .71$; this is further explored below. No significant main effects of waist category were found, nor any significant interactions ($p > .05$).

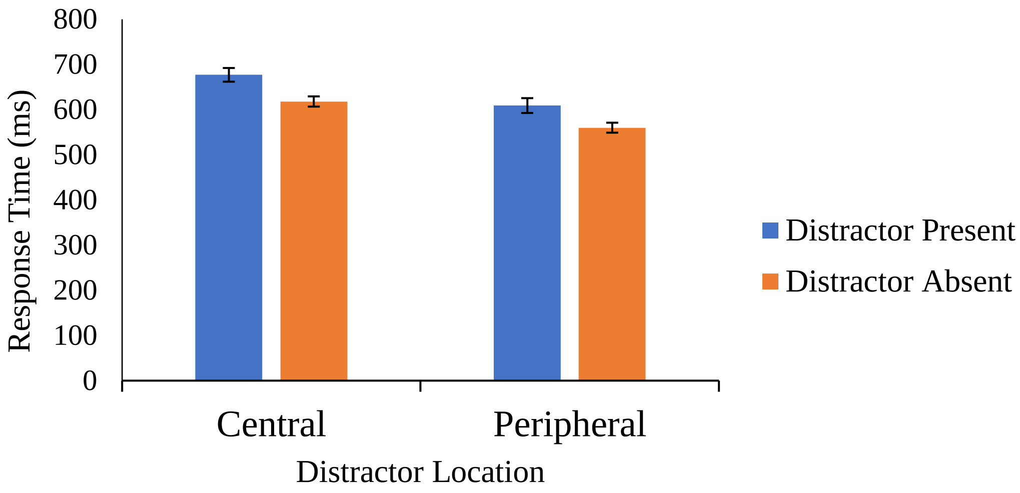

Figure 8. Mean Response time (ms) for central and peripheral trials when the distractors are both present and absent.

Following this analysis, central and peripheral RT data were analysed separately to explore the significant main effect of image category found above. Firstly, the central data was entered into a contrast analysis to compare each image category (high calorie, low calorie, household objects) with the distractor absent category. When presented centrally, high calorie, F (1, 58) = 46.78, p <.001, $\eta p2$ = .45, low calorie, F (1, 58) = 79.95, p <.001, $\eta p2$ = *.58*, and household objects, F (1, 58) = 73.46, p <.001, $\eta p2$ = .56, all produced significant distraction. Peripheral data were also analysed similarly. High calorie (F (1, 58) = 45.15, p <.001, $\eta p2$ = .44), low calorie (F (1, 58) = 43.63, p <.001, $\eta p2$ = *.43*) and household objects (F (1, 58) = 40.97, p <.001, $\eta p2$ = .41) all produced significant distraction. No significant main effects or interactions involving waist circumference were found.

Response Times (RTs) were then used to determine distraction (distraction index) by subtracting the distractor absent trial RTs from the distractor present trial RTs (distractor present – distractor absent) for images of the same image category. The distraction index controls for individual differences in overall RTs. Central and peripheral distraction indices (distractor present trials – distractor absent trials to control for individual differences in overall RTs) were analysed separately. This was done to determine whether participants were significantly more distracted by high calorie images compared to low calorie and household object images. Central distraction indices were entered into a 3 (image category: high calorie, low calorie, household object images) x 2 (waist category: large vs. small) mixed measures ANOVA. No significant main effects or interactions were found (all $p > .05$). Thus, for central trials participants were not significantly more distracted by high calorie images compared to low calorie and household object images (see Figure 9). Nor did waist circumference moderate the effect. Peripheral distraction index data were also entered into a 3 (image category: high calorie, low calorie, household object images) x 2 (waist category: large vs. small) mixed measures ANOVA. No significant main effects or interactions were found ($p > .05$). Thus, for peripheral trials participants were not significantly more distracted by high calorie images compared to low calorie and household object images (see Figure 9). Nor did waist circumference moderate the effect.

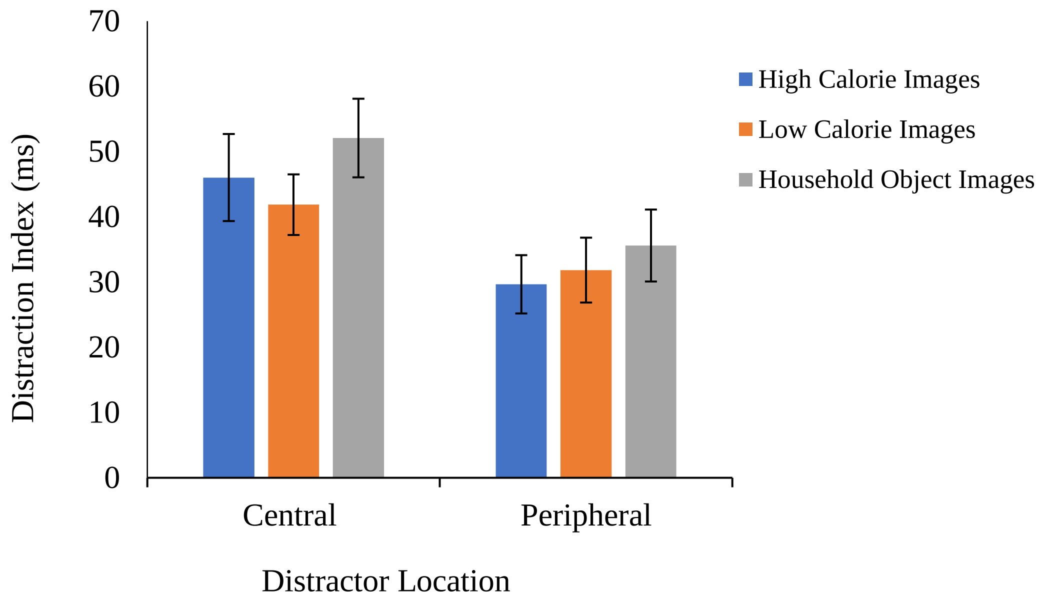

Figure 9. Mean distraction level (ms) by image category when distractors are presented centrally and peripherally.

These results indicate that participants exhibited both a distraction effect (participants were significantly slower on distractor present trials compared to distractor-absent trials) and a distractor location effect (participants were significantly slower when distractors were presented centrally compared to in the periphery). However, no significant evidence was found to suggest that participants exhibited an attentional bias towards food images (either high calorie or low-calorie foods). Additionally, waist circumference does not appear to be related to an attentional bias towards food images.

Accuracy

Accuracy rates were high on both Central (*M* = 94.75, *SD* = 3.84) and Peripheral (*M* = 95.91, *SD* = 3.33) versions of the task in Experiment 2 (see Table 7). Central and peripheral accuracy data were entered into a 2 (distractor location: central, peripheral) x 4 (image category: high calorie images, low calorie images, household object images, no images) x 2 (waist category: large, small) mixed measures ANOVA. No significant main effects or interactions were found (p >.05). These results suggest that for both central and peripheral trials, participants were not significantly more accurate on distractor-present trials compared to distractor-absent trials. These results lend further support to the fact that the accuracy effects in Experiment 1 were unlikely a reflection of an attentional bias towards food.

Table 7

Mean (SD) accuracy (%) for central and peripheral versions of the distraction task, by image category and distractor presence in Experiment 2.

Condition	Accuracy	Total Accuracy
Central Distractors		0.95 (0.04)
Distractor Absent	0.96 (0.04)	
High Calorie	0.96 (0.05)	
Low Calorie	0.95 (0.06)	
Household Objects	0.96 (0.05)	
Peripheral Distractors		0.96 (0.03)
Distractor Absent	0.96 (0.03)	
High Calorie	0.96 (0.05)	
Low Calorie	0.96 (0.06)	
Household Objects	0.96 (0.05)	

Note. Total accuracy = the average total accuracy score for all participants across all 8 blocks on central and peripheral trials (including both distractor present and absent trials). (N=60).

Exploratory Analyses

Experiment 2 also sought to understand the relationship between hunger and attentional biases towards food. To do so, participants were asked to subjectively rate their own hunger levels before doing the task (time 1) and after doing the task (time 2). Participants were significantly hungrier, $t(59) = -5.56$, $p < .001$, at time 2 ($M = 3.82$, $SD = 1.02$) compared to time 1 ($M = 3.35$, $SD = .92$). No significant correlations were observed between hunger (at either time 1 or 2) and distraction by any image category for either central or peripheral trials (See Table 8).

Table 8

Correlations between Hunger (Time 1 and Time 2) and Image Category (High calorie, Low calorie, Household object images) for central and peripheral distractor trials

Image Category	Hunger-Time 1	Hunger-Time 2
Central Distractor Trials		
High Calorie Images	.03 (*p* = .81)	.05 (*p* = .73)
Low Calorie Images	-.03 (*p* = .83)	.08 (*p* = .53)
Household Object Images	.04 (*p* = .78)	.04 (*p* = .79)
Peripheral Distractor Trials		
High Calorie Images	.18 (*p* = .17)	.05 (*p* = .69)
Low Calorie Images	.04 (*p* = .76)	-.04 (*p* = .75)
Household Object Images	-.06 (*p* = .64	-.07 (*p* = .60)

Additionally, no significant correlations were found between hunger (at either time 1 or 2) and accuracy by any image category for either central or peripheral trials (See Table 9). Lastly, the relationship between hunger (Time 1 and Time 2) and waist circumference was investigated. Hunger at both time 1, $r(60) = -.002$, $p = .99$, and time 2, $r(60) = -.02$, $p = .89$, did not significantly correlate with waist circumference.

Table 9

Correlations between participants' accuracy (on both central and peripheral trials) and hunger (Time 1 and Time 2).

Accuracy	Hunger: Time 1	Hunger: Time 2
Central Trials	-.06 (*p* = .64)	-.14 (*p* = .31)
Peripheral Trials	.05 (*p* = .70)	.02 (*p* = .88)

Summary

Experiment 2 sought to investigate the existence of an attentional food-related bias. Unlike Experiment 1, Experiment 2 conceptually replicated the work of Cunningham & Egeth (2018) by including peripheral trials (and central trials). Distractor location was manipulated to enhance our ability to detect an attentional bias towards food stimuli. Additional improvements to the methodology were made such as increasing the period of pre-task fasting, increasing the number of trials, and using distractor absent trials to determine distraction index (rather than "Scrambles").

We predicted participants would show a stronger attentional bias towards food-related stimuli compared to non-food stimuli. Additionally, that the attentional bias towards food would be related to the factors of waist circumference and self-reported hunger. However, no significant main effects, interactions, or correlations were found suggesting that waist circumference and self-reported hunger do not appear to be related to an attentional bias towards food.

Moreover, no significant main effects or interactions were found with the accuracy data. This further suggests that participants within our experiment did not exhibit an attentional bias towards appetitive food stimuli.

Whilst we did not obtain significant support for the existence of an attentional bias towards food, we still obtained significant distraction. Participants were significantly slower to complete the task (significantly distracted) when they were presented with images compared to no image trials. Additionally, a significant distractor location effect was also obtained; participants were significantly slower to complete the task when trials contained central, compared to peripheral distractor images. These results suggest that the absence of a significant attentional bias towards food is likely due to the nature of the images, and not methodological weakness. This is because participants still exhibited the robust distraction and distractor-location effects we see consistently throughout the literature (Walsh et al., 2018). However, distraction level is not increasing for food-related images the way it does when emotional images are presented. This suggests it is the semantic nature of the food images that is inhibiting an attentional bias from emerging.

Evidently, the results of Experiment 2 do not align with Cunningham & Egeth (2018) who found significant evidence for an attentional bias towards food stimuli. Whilst we conceptually replicated their study there were several differences that could account for the differing results. For example, both studies used adapted versions of distraction tasks created by Forster & Lavie (2008a, 2008b, 2011). However, they were still two distinct tasks which could account for the differing results.

In Cunningham & Egeth's task participants are placed under heavier load and are asked to make 4 alphanumerical distinctions. In our task participants only have to decide if a target is a 'K' or an 'N'. Previous research has shown that when participants are placed under greater attentional load, they exhibit a significant decrease in distraction (Van Dillen, Papies & Hofmann, 2013). Therefore, we should have been *more* likely to find a stronger attentional food bias compared to Cunningham & Egeth because our participants were placed under lesser load. Thus, it appears improbable that our differing results are due to the task we used.

Another potential reason could be differences in sample size. Cunningham & Egeth (2018) utilised a smaller sample size (N = 18) than both Experiment 1 (N = 52) and Experiment 2 (N = 60). Although they argue their sample size was selected based on a power analysis, it is small compared to other studies that have examined attentional biases towards food stimuli (Kakoschke, Kemps & Tiggemann, 2015; Seibt, Hafner & Deutsch, 2007; Stewart & Samoluk; 1997; Van Dillen, Papies & Hofmann, 2013). For example, Stewart & Samoluk (1997) used 32 participants within their research and found no significant support for the existence of an attentional bias towards food. Furthermore, Van Dillen Papies & Hoffmann (2013) used between 49-107 participants for each of their 4 experiments and found that participants showed stronger attentional biases towards food stimuli when under low cognitive load. However, when placed under high cognitive load the bias disappeared. Thus, it is possible that the significant findings of Cunningham & Egeth (2018) were merely due to chance and are not an accurate statistical representation of the general population. Furthermore, Cunningham & Egeth also appear to make the attentional bias effect disappear in their second experiment, with only a weak manipulation of hunger (2 small chocolate bars). This further supports the possibility that their findings may merely be due to chance.

General Discussion

People exhibit strong attentional biases towards emotional stimuli (Pourtois et al., 2013; Vuilleumier, 2005; Walsh et al., 2018). Presentation of emotional stimuli will rapidly and automatically capture attention, often disrupting performance (Sander at al., 2005). Emotion-related attentional biases are advantageous to survival, promoting either approach or avoidance responses depending on the situational context (Berridge & Kringelback, 2008; Pool et al., 2016). However, majority of past research investigating emotion-related attentional biases utilise the same positive (erotic images) and negative (mutilation images) stimuli (Grimshaw et al., 2018; Kranz, 2015; Murphy, 2016; Padmala et al., 2018; Piech et al., 2011; Walsh et al., 2018). Thus, it is unclear whether attentional biases exist towards other emotional, motivationally-relevant stimuli (e.g. food).

In this thesis I examined the existence of a food-related attentional bias and its association to both state and trait factors. Experiment 1 sought to search for the existence of a food-related attentional bias by having participants complete an irrelevant distraction task (adapted from Walsh et al., 2018). Participants were asked to fast for 2 hours to increase hunger levels and promote bias detection.

In Experiment 2, the effect of the relative position of the targets and distractors was tested to provide a conceptual replication of Cunningham & Egeth (2018). Cunningham & Egeth used central targets and peripheral distractors and obtained a significant attentional bias towards food stimuli. Specifically, they found support for a stronger attentional bias towards high calorie food stimuli compared to low calorie and non-food stimuli. Other methodological concerns were also rectified in Experiment 2. Community participants were recruited and asked to fast for 4 hours in an attempt to increase self-reported hunger. The same distraction task used in Experiment 1 was completed by all participants. However, blocked central and peripheral trials were included to manipulate distractor-relevance.

Behavioural Results

In Experiment 1, participants exhibited a significant distraction effect; participants were slower to perform the task when intact images (compared to scrambles) were presented. However, no distraction differences were found in relation to the differing image categories (high calorie, low calorie and household objects). Furthermore, trait factors (waist circumference) were not found to be significantly associated with a food-related attentional bias.

The experimental design of Experiment 2 closely followed that of Experiment 1, with the addition of peripheral distractors. Similar results were obtained. Participants exhibited both a significant distraction effect and distractor location effect (participants were slower to perform the task when central distractors were presented, compared to peripheral distractors). However, no distraction differences were found in relation to the differing image categories. Once again, trait factors (waist circumference) were not found to be significantly associated with a food-related attentional bias.

In Experiment 1, we postulated that the absence of a significant food-related attentional bias may have been caused by distractor location (central distractors may attenuate the bias). However, this explanation cannot account for the pattern of behavioural data obtained in experiment 2 as both central and peripheral trials were included.

Exploratory Results

In both Experiments 1 and 2, self-reported hunger did not significantly correlate with either high calorie, low calorie or household object distraction. Despite the longer fasting period in Experiment 2, self-reported hunger still did not appear to be associated with a food-related attentional bias.

Despite the null findings of Experiment 1 and 2, this study still makes an important contribution to the literature. We found no significant evidence to suggest that an attentional bias towards food stimuli exists. However, previous studies (Channon & Hayward, 1990; Cunningham & Egeth, 2018; Mogg, Bradley, Hyare & Lee, 1998) did find support for the existence of a food-related attentional bias. Our opposing results call in to question the reliability of these past studies as well as our own.

Cunningham & Egeth (2018) discovered that participants' performance on an irrelevant distraction task was significantly more disrupted when shown food images compared to non-food images. Furthermore, participants exhibited a stronger attentional bias towards high calorie food images, compared to low calorie and non-food images. Interestingly, in their second experiment Cunningham & Egeth asked an additional 18 participants to consume two small chocolate bars prior to completing the task. Participants were significantly less distracted by the high calorie food images compared to the participants in their first Experiment (who did not consume chocolate). Thus, Cunningham & Egeth (2018) argue that a food-related attentional bias is pliable and can be significantly reduced after chocolate bar consumption.

Despite our conceptual replication attempts, our results did not align with those of Cunningham & Egeth (2018). No significant evidence was found to support the existence of an attentional bias towards food stimuli. One reason for our differing results could be due to differences in the tasks utilised. Both tasks were adapted versions of tasks created by Forster & Lavie (2008a, 2008b, 2011). However, the tasks did differ slightly. Cunningham & Egeth asked participants to make four alphanumeric target decisions, whilst presenting distractor images in the periphery of the display.

Within our task, participants were asked to make one target decision whilst distractors were presented in the centre or periphery of the display.

Cunningham & Egeth's task was more complex and placed participants under greater cognitive load (compared to our task). Due to greater cognitive load demands one would therefore expect distraction effects to be *less* likely to emerge in Cunningham & Egeth's study (compared to ours). Previous research has shown that increases in cognitive load lead to a reduction in distractibility for participants (Gupta, Hur & Lavie, 2016; Van Dillen, Papies & Hofmann, 2013). Thus, it would appear improbable that our lack of a significant distraction effect is due to the type of task we employed; our task was an easier, less demanding version of that used by Cunningham & Egeth (2018). Therefore, performance on our task should be more susceptible to disruption by irrelevant distractors.

Additionally, Cunningham & Egeth (2018) used a smaller sample size than both of our Experiments (1 and 2), and several other studies (Kakoschke, Kemps & Tiggemann, 2015; Seibt, Hafner & Deutsch, 2007; Stewart & Samoluk; 1997; Van Dillen, Papies & Hofmann, 2013) that examined food-related attentional biases. Consequently, their results may not be credible due to their underpowered design. Small, under-powered studies are more susceptible to both false positives and false negatives (Button et al., 2013). Thus, it is difficult to ascertain the credibility of Cunningham & Egeth's results.

Evidently, Cunningham & Egeth's design was not as methodologically sound as it first appeared. However, their methodological shortcomings are not the only points in the literature that call in to question the existence of a food-related attentional bias. Channon & Hayward (1990) found significant disruption to performance on the food version of the stroop task, following food-deprivation. However, Stewart & Samoluk (1997) failed to replicate this effect. Moreover, attentional biases towards food stimuli have been shown to emerge only under certain conditions. Lavy & Van Den Hout (1993) found a significant food-related attentional bias when holiday words were used as control stimuli, but not when tool words were used. These results suggest that if a food-related attentional bias does exist, it is not strong or robust, and may only emerge under specific conditions.

Additionally, a food-related attentional bias may only emerge in highly restrained eaters. This specific population has been shown to exhibit disrupted performance on the food-version of the stroop task (Green & Rogers, 1993). However, healthy controls exhibited no disruptions to performance. These findings further support the notion that a food-related attentional bias may only emerge under specific conditions; a food-related attentional bias may exist only in those with a disordered mindset towards food.

Lastly, food-related attentional biases may only be detected when the task stimuli have certain properties. Using a visual search task, participants were faster to detect both appetizing and bland food stimuli compared to non-food stimuli (Nummenmaa, Hietanen, Calvo & Hyona, 2011). Therefore, participants exhibited significant attentional biases towards food stimuli. However, in their second Experiment, all stimuli (both food and non-food images) were strictly matched in terms of visual composition. This caused the bias to disappear completely, enhancing the likelihood that a food-related attentional bias may only emerge under certain conditions.

Because the literature is so muddy and there is support both for and against a food-related attentional bias, it is difficult to make sound conclusions. However, we conducted two pre-registered studies, utilising larger than typical samples, and a distraction task that has been consistently shown to demonstrate greater distraction by emotional compared to neutral images (Grimshaw et al., 2018; Walsh et al., 2018). Thus, our results were derived through strong methodological practice. Based on the results we obtained, we support the argument that a food-related attentional bias does not exist, or exists only under strict conditions.

However, one must still be willing to explore the possibility that any null findings obtained could be because of one's own methodological short-comings. Thus, it is important to discuss the limitations present within our studies that could be hindering our ability to obtain a significant effect.

Limitations

The current studies were designed to assess attentional biases towards food stimuli, using an irrelevant distractor paradigm. All food stimuli used in both Experiment 1 and 2 can be considered appetitive (they satisfy bodily needs). However, when selecting the food stimuli, we did not consider human variability with regards to specific dietary requirements and/or dietary preferences. This is a potential problem as a subset of people (16 participants in Experiment 1, 24 participants in Experiment 2) reportedly ate an "atypical" diet. Thus, the stimuli used may not have had the intended effect for a notable portion of our participants. For example, if the majority of these participants lead a vegetarian/vegan lifestyle then foods containing animal products would be less likely to capture their attention; animal/meat-related images would not possess the same motivational value. These foods are not viewed as necessary to their survival, hence why they do not consume them. It is entirely possible that the attentional and reward circuits within the brains of those who consume atypical diets have adapted.

Thus, they no longer automatically orient to such stimuli as they offer no additional advantage to their survival. Consequently, the absence of a significant food-related attentional bias may be due to the food stimuli used and/or the presence of participants who consume atypical diets.

Insufficient hunger levels may have also contributed to the null findings of Experiments 1 and 2. Whilst we tried to correct this limitation in Experiment 2 by increasing the fasting period, this did not produce massive hunger effects. If participants were not hungry, then food may have lost its motivational value; the need to seek out a food source would no longer be of high priority (Seibt, Hafner & Deutsch, 2007). Consequently, participants did not exhibit a significant attentional bias towards food as it would offer no additional survival value (at that time period).

A food-related attentional bias may still exist, but only towards actual food stimuli (e.g. a slice of cake). Food images may not have the power to capture attention the way that real-world foods would. After all, eating is multi-sensory (Spence, 2015). Food images alone may not capture all aspects required for a food-related attentional bias to arise. To test the hypothesis that real foods may produce greater distraction effects, one could utilise eye-tracking whilst having participants complete a distraction task that incorporates real-food stimuli. If participants exhibit significant distraction towards real-food stimuli (compared to non-food stimuli), then a food-related attentional bias is possibly driving that distraction. Additionally, eye movements have been linked to attentional focus (Zhao, Gersch, Schnitzer, Dosher & Kowler, 2012). Thus, if participants direct their gaze more rapidly and/or exhibit longer gaze durations towards real food, then a food-related attentional bias might be responsible. Such an experiment would provide further insight into whether a food-related attentional bias exists.

Despite these limitations, there were several strengths of the experimental research which help bolster the results we derived. Firstly, both Experiment 1 and 2 were pre-registered on AsPredicted (Simonsohn, Simmons & Nelson, 2015). This allows readers to have greater faith in the results we obtained. Pre-registration eliminates the potential for things such as “p-hacking” (manipulation of data to achieve significant results; Simmons, Nelson & Simonsohn, 2011) and “HARKing” (Hypothesising after results are known; Kerr, 1998) to occur. Thus, the results presented have been obtained through transparent and reliable practices.

Additionally, the distraction task we used is well-established in the emotional distraction literature (Gupta, Hur & Lavie, 2016). Several studies in our own lab have used the same task to show that participants exhibit stronger attentional biases towards emotional compared to neutral images (Grimshaw et al., 2018; Kranz, 2015; Murphy, 2016; Walsh et al., 2018). Furthermore, in our own study significant distraction effects were obtained. Thus, the task we used was well suited to detect a food-related attentional bias. However, a significant attentional bias towards food was not obtained; the absence of a food bias is more likely due to the semantic nature of the stimuli and not the task itself.

Lastly, both IPRP (first year psychology students) and community participants were used to investigate the existence of a food-related attentional bias. Thus, we assessed for the existence of a food bias in a wide variety of people. Consequently, the null effects we obtained were not likely due to the participant pools we sampled from.

Future Directions

Future studies should look to rectify the limitations previously identified. Firstly, it is important to systematically address the dietary variation that exists across individuals. Participants who consume atypical diets should either be excluded from the study or complete the task with an adapted stimulus set. The food images in the stimulus sets should correspond to the type of diet the participant consumes. For example, a vegan participant could be shown high calorie vegan foods as part of the energy-dense stimulus set. Alternatively, participants could rate all of the food images on palatability and/or pleasantness to ensure the images are having the intended effect. If the images were found to be unsatisfactory and not capable of capturing attention the way we had intended, a new stimulus set (containing food images) should be considered e.g. The food images from the IAPS (Lang, Bradley & Cuthbert, 2008). However, if it is the static nature of the images that is preventing attentional capture, one could also consider utilising food videos that contain an element of motion (e.g. steam rising from a hot pizza). This may enhance ecological validity as it could make the food stimuli seem more ‘real-world-like’.

Future researchers should consider extending the fasting period to further increase self-reported hunger. Ultimately, 2-4 hours of food deprivation did not cause massive bouts of hunger within our participants. Most participants felt little to no effect of the deprivation period. Thus, it is possible that a significant attentional bias towards food may only emerge in those who are truly hungry (e.g. 24 hours of food-deprivation). One cannot rule out this possibility without comparing a ‘true hunger’ group to a sated group of people, on the distraction task.

Lastly, future research could investigate the existence of a food-related attentional bias in clinical populations. Clinical groups (patients who scored high on restrained eating and drive for thinness) have been shown to exhibit greater colour-naming disruption on the food-stroop task, compared to healthy, non-restrained controls (Ben-Tovim et al., 1989; Ben-Tovim & Walker, 1991; Green & Rogers, 1993; Perpina, Hemsley, Treasure & de Silva, 1993; Stewart & Samoluk, 1997). Patients with disordered eating often exhibit greater preoccupation with food. Restrained eating patterns can also cause cognitive changes with regards to the processing of food stimuli (Perpina et al., 1993). Consequently, an attentional bias towards food stimuli may be more reflective of internal worry regarding food intake rather than craving/hedonic motivation to seek out a pleasurable food source; as we originally hypothesised (Werthmann, Jansen & Roefs, 2014). Thus, it is possible that a food-related attentional bias may only emerge in clinical populations with a disordered mindset towards food.

Conclusions

In this thesis I sought to examine one cognitive mechanism (attentional bias) that might contribute to the dire over-eating problem crippling NZ society. Attentional biases are rapid and automatic (Kakoschke & Deutsch, 2004) and are known to exist towards highly emotional stimuli (Pool et al., 2016; Walsh et al., 2018). Attentional biases towards emotional stimuli are motivationally relevant and are adaptive to survival. We hypothesised that a similar attentional bias might exist towards food stimuli. Arguably, a food-related attentional bias should emulate an emotion-bias as both would be motivationally relevant and adaptive to survival. However, this food-related attentional bias may be heightened in certain individuals. A strong attentional bias towards food could produce hyper-awareness towards food stimuli in the environment, which may trigger excessive food consumption; ultimately resulting in unhealthy weight gain.

Several past researchers obtained significant support for the existence of a food-related attentional bias. However, this thesis found no evidence to suggest that people exhibit stronger attentional biases towards food over non-food stimuli. Additionally, people do not appear to exhibit significant distraction by high calorie food images. Despite the absence of a significant food-related attentional bias, we did obtain a significant distraction effect in both Experiment 1 and 2. A significant distractor location effect was also obtained in Experiment 2. These results allude to the fact that the task was appropriate for detecting an attentional bias (if a bias was present). These results also suggest that the absence of an attentional bias is likely due to the semantic nature of the food stimuli. Thus, food images do not appear to capture attention in the same manner as highly emotional images (e.g. erotica, mutilation). Furthermore, it is also possible that a food-related attentional bias does not exist or exists only under certain conditions (Green & Rogers, 1993; Lavy & Van Den Hout, 1993; Nummenmaa, Hietanen, Calvo & Hyona, 2011; Stewart & Samoluk, 1997).

The research conducted in this thesis calls in to question the plausibility of an attentional bias towards food stimuli. Are people truly equipped with an automatic attentional mechanism that causes them to rapidly orient towards a food stimulus? Despite such a bias being theoretically sound (it would be evolutionarily advantageous for survival) the current research found no evidence for its existence. Furthermore, this research does not answer the question of whether this cognitive mechanism has a role to play in the obesity epidemic. However, it does provide valuable insight for those wishing to explore the bias and address such a question in future experiments.

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Appendix A

Pre-registration documents for Experiment 1 and Experiment 2

Experiment 1 Pre-Registration Document

Experiment 1 Pre Registration .pdf

Experiment 2 Pre-Registration Document

Experiment 2 Pre Registration pdf.pdf

Appendix B

A list of all images taken from the FoodPics database and used in Experiment one

Image Number in Database	Item Description	Item Category	Trial Type
2	Hamburger	High Calorie	Practice Trial
13	Frankfurt Crown Cake	High Calorie	Experimental Trial
15	Croissants	High Calorie	Experimental Trial
16	Pancakes	High Calorie	Practice Trial
17	Cheeseburger, Fries, Cola	High Calorie	Experimental Trial
19	German Krapfen	High Calorie	Experimental Trial
22	French Fries	High Calorie	Experimental Trial
27	Opened Chips Bag	High Calorie	Experimental Trial
29	Cake	High Calorie	Experimental Trial
30	French Fries, Chicken	High Calorie	Experimental Trial
34	Ham & Cheese Sandwich	High Calorie	Experimental Trial
42	Chocolate Cake with Nuts	High Calorie	Experimental Trial
48	Chocolate Muffin	High Calorie	Experimental Trial
49	Chocolate Popsicles	High Calorie	Experimental Trial
50	Donuts & Pastries	High Calorie	Experimental Trial
52	Hot Dog	High Calorie	Practice Trial
55	Raspberry Cake	High Calorie	Experimental Trial
61	Pizza (Salami)	High Calorie	Practice Trial
82	Cheese Platter	High Calorie	Experimental Trial
85	Pizza (Salami)	High Calorie	Experimental Trial

90	Muffins	High Calorie	Experimental Trial
95	Raspberry Cake	High Calorie	Experimental Trial
98	Cheese Platter	High Calorie	Experimental Trial
100	Chocolate Cake	High Calorie	Practice Trial
115	Sundae (with Raspberries)	High Calorie	Practice Trial
128	Hard Candies	High Calorie	Experimental Trial
131	Pizza (Veggie/Cheese)	High Calorie	Experimental Trial
144	Pasta Bake	High Calorie	Experimental Trial
152	Peanut Puffs	Low Calorie	Experimental Trial
155	Crackers	Low Calorie	Experimental Trial
180	Muesli Bar (Oatmeal)	Low Calorie	Experimental Trial
182	Bowl of Rice	Low Calorie	Practice Trial
186	Pretzel Sticks	Low Calorie	Experimental Trial
192	Apple	Low Calorie	Experimental Trial
193	Crisp Bread	Low Calorie	Experimental Trial
194	Kiwi	Low Calorie	Practice Trial
196	Salad Plate	Low Calorie	Practice Trial
197	Tomatoes	Low Calorie	Experimental Trial
201	Salad Plate	Low Calorie	Experimental Trial
206	Raspberries	Low Calorie	Experimental Trial
213	Crisp Bread with Cottage Cheese	Low Calorie	Experimental Trial
215	Cucumber with Carrot	Low Calorie	Experimental Trial
221	Oranges	Low Calorie	Practice Trial

229	Salad Plate	Low Calorie	Practice Trial
250	Broccoli	Low Calorie	Practice Trial
252	Lettuce (Iceberg)	Low Calorie	Experimental Trial
253	Pickles	Low Calorie	Experimental Trial
258	Radishes	Low Calorie	Experimental Trial
259	Red Cabbage	Low Calorie	Experimental Trial
288	Carrots	Low Calorie	Experimental Trial
290	Bars of White Chocolate	High Calorie	Experimental Trial
321	Egg, Boiled	Low Calorie	Experimental Trial
332	Mixed Salad	Low Calorie	Experimental Trial
334	Carrots	Low Calorie	Experimental Trial
348	Rusk	Low Calorie	Experimental Trial
372	Breakfast Cereals	Low Calorie	Experimental Trial
383	Ravioli	Low Calorie	Experimental Trial
394	Grapes	Low Calorie	Experimental Trial
417	Pea Pod	Low Calorie	Experimental Trial
492	Vanilla & Chocolate Ice Cream	High Calorie	Experimental Trial
1007	Red Bucket	Household Object	Experimental Trial
1009	Light Bulb	Household Object	Experimental Trial
1011	Towel	Household Object	Experimental Trial
1012	Cushion	Household Object	Experimental Trial
1013	Clothes Hanger	Household Object	Practice Trial
1014	Ladder	Household Object	Practice Trial

1036	Sponge	Household Object	Experimental Trial
1132	Tape	Household Object	Experimental Trial
1135	Bucket	Household Object	Experimental Trial
1198	Toilet Tissue	Household Object	Experimental Trial
1200	Watering Can	Household Object	Experimental Trial
1204	Bowl with Open Lid	Household Object	Experimental Trial
1210	Chair	Household Object	Experimental Trial
1213	Hand Brush	Household Object	Experimental Trial
1217	Clay Pot	Household Object	Experimental Trial
1218	Chair	Household Object	Experimental Trial
1223	Wooden Case	Household Object	Experimental Trial
1235	Basket	Household Object	Experimental Trial
1237	Basket	Household Object	Experimental Trial
1240	Umbrella	Household Object	Experimental Trial
1247	Bunch of Keys	Household Object	Experimental Trial
1249	Sponge	Household Object	Experimental Trial
1251	Paint Brush	Household Object	Practice Trial
1261	Plastic Container	Household Object	Experimental Trial
1262	Paint Roller	Household Object	Practice Trial
1267	Electric Bulb	Household Object	Practice Trial
1271	Drainer	Household Object	Practice Trial
1273	Cabinet	Household Object	Experimental Trial
1277	Candle	Household Object	Experimental Trial

1279	Candle	Household Object	Experimental Trial

Appendix C

Instructions given to participants regarding how to obtain their own waist measurement

1. Stand up straight with both of your feet placed firmly on the floor.
2. Find the top of your hip bone and the bottom of your ribs (the point should be just above your bellybutton).
3. Breathe out normally
4. Place the tape measure midway between these points and wrap it around your waist
5. Check your measurement
6. Record your measurement (in cm) in the top right-hand corner of your hunger questionnaire

Appendix D

A list of all images taken from the FoodPics database and used in Experiment Two

Image Number in Database	Item Description	Image Category	Trial Type
2	Hamburger with bacon	High Calorie	Experimental Trial
12	Ham sandwich	High Calorie	Practice Trial
13	Frankfurt crown cake	High Calorie	Experimental Trial
15	Croissants	High Calorie	Experimental Trial
16	Pancakes	High Calorie	Experimental Trial
17	Cheese burger, french fries and cola	High Calorie	Experimental Trial
19	German krapfen	High Calorie	Experimental Trial
22	French fries	High Calorie	Experimental Trial
24	Ice cream sandwiches	High Calorie	Practice Trial
27	Opened chips bag	High Calorie	Experimental Trial
29	Cake (with gelatinized fruits)	High Calorie	Experimental Trial
30	French fries, chicken	High Calorie	Experimental Trial

34	Ham and cheese sandwich	High Calorie	Experimental Trial
42	Chocolate cake with nuts	High Calorie	Experimental Trial
47	French fries and chicken drumsticks	High Calorie	Experimental Trial
48	Chocolate muffin	High Calorie	Experimental Trial
49	Chocolate popsicles	High Calorie	Experimental Trial
50	Donuts and pastries	High Calorie	Experimental Trial
52	Hot dog	High Calorie	Experimental Trial
54	Cheese platter	High Calorie	Experimental Trial
55	Raspberry cake	High Calorie	Experimental Trial
59	Apple Pie	High Calorie	Practice Trial
61	Pizza (salami)	High Calorie	Experimental Trial
65	Cheese burger	High Calorie	Experimental Trial
81	Pizza slices (assorted)	High Calorie	Practice Trial
82	Cheese platter	High Calorie	Experimental Trial

85	Pizza (with salami)	High Calorie	Experimental Trial
90	Muffins	High Calorie	Experimental Trial
92	Cheddar cheese	High Calorie	Experimental Trial
93	Muffins	High Calorie	Experimental Trial
95	Raspberry cake	High Calorie	Experimental Trial
96	Cake	High Calorie	Practice Trial
98	Cheese platter	High Calorie	Experimental Trial
99	Cake	High Calorie	Practice Trial
100	Chocolate cake	High Calorie	Experimental Trial
115	Sundae (with raspberries)	High Calorie	Experimental Trial
125	Hard candies	High Calorie	Experimental Trial
128	Hard candies	High Calorie	Experimental Trial
131	Pizza (veggie/cheese)	High Calorie	Experimental Trial
142	Pasta bake	High Calorie	Experimental Trial
144	Pasta bake	High Calorie	Experimental Trial

152	Peanut puffs	Low Calorie	Experimental Trial
155	Crackers	Low Calorie	Experimental Trial
176	Salami sausage	High Calorie	Experimental Trial
180	Muesli bar (oatmeal)	Low Calorie	Experimental Trial
181	Bowl of muesli (granola)	High Calorie	Experimental Trial
182	Bowl of rice	Low Calorie	Experimental Trial
186	Pretzel sticks	Low Calorie	Experimental Trial
192	Apple	Low Calorie	Experimental Trial
193	Crisp bread	Low Calorie	Experimental Trial
194	Kiwi	Low Calorie	Experimental Trial
195	Cucumber slice	Low Calorie	Experimental Trial
196	Salad plate	Low Calorie	Experimental Trial
197	Tomatoes	Low Calorie	Experimental Trial
199	Watermelon	Low Calorie	Experimental Trial

201	Salad plate	Low Calorie	Experimental Trial
202	Blueberries	Low Calorie	Practice Trial
203	Wildberries mix	Low Calorie	Practice Trial
206	Raspberries	Low Calorie	Experimental Trial
213	Crisp bread with cottage cheese	Low Calorie	Experimental Trial
215	Cucumber and carrot	Low Calorie	Experimental Trial
219	Salad plate	Low Calorie	Experimental Trial
221	Oranges	Low Calorie	Experimental Trial
225	Crisp bread with cottage cheese	Low Calorie	Practice Trial
228	Bowl of salad	Low Calorie	Practice Trial
229	Salad plate	Low Calorie	Experimental Trial
240	Crisp bread with cottage cheese	Low Calorie	Experimental Trial
247	Green paprika peppers	Low Calorie	Experimental Trial
250	Broccoli	Low Calorie	Experimental Trial

252	Lettuce (iceberg)	Low Calorie	Experimental Trial
253	Pickles	Low Calorie	Experimental Trial
255	Pomegranate	Low Calorie	Practice Trial
258	Radishes	Low Calorie	Experimental Trial
259	Red cabbage	Low Calorie	Experimental Trial
260	Asparagus	Low Calorie	Experimental Trial
262	Celery	Low Calorie	Experimental Trial
263	Mushrooms (brown)	Low Calorie	Practice Trial
265	Zucchini	Low Calorie	Experimental Trial
266	Green onion (shallot)	Low Calorie	Experimental Trial
267	Cucumber with slices	Low Calorie	Experimental Trial
288	Carrots	Low Calorie	Experimental Trial
290	Bars of white chocolate	High Calorie	Experimental Trial
303	Cauliflower	Low Calorie	Experimental Trial
321	Egg, boiled	Low Calorie	Experimental Trial

332	Mixed salad	Low Calorie	Experimental Trial
334	Carrots	Low Calorie	Experimental Trial
348	Rusk	Low Calorie	Experimental Trial
355	Cream cake with fruits	High Calorie	Experimental Trial
362	Beans and carrots, cooked	Low Calorie	Experimental Trial
372	Breakfast cereals	Low Calorie	Experimental Trial
383	Ravioli	Low Calorie	Experimental Trial
387	Goose, roasted	High Calorie	Experimental Trial
394	Grapes	Low Calorie	Experimental Trial
417	Pea pod	Low Calorie	Experimental Trial
419	Strawberry cream cake	High Calorie	Experimental Trial
426	Bread	High Calorie	Experimental Trial
430	Head of iceberg lettuce	Low Calorie	Experimental Trial
446	Tomato, sliced	Low Calorie	Experimental Trial

455	Spinach	Low Calorie	Experimental Trial
471	French toast	High Calorie	Experimental Trial
480	Rolls in a basket	High Calorie	Experimental Trial
485	Burger patty with french fries and salad	High Calorie	Experimental Trial
491	Sundae	High Calorie	Experimental Trial
492	Vanilla and chocolate ice-cream cone	High Calorie	Experimental Trial
494	Pretzel	Low Calorie	Experimental Trial
522	Vegetables	Low Calorie	Experimental Trial
545	Shrimp	Low Calorie	Experimental Trial
568	Salami, roasted ham and cheese	High Calorie	Experimental Trial
1004	Shoe brush	Household Object	Experimental Trial
1005	Hair brush	Household Object	Experimental Trial
1007	Red bucket	Household Object	Experimental Trial
1008	Yellow bucket	Household Object	Experimental Trial

1009	Light bulb	Household Object	Experimental Trial
1011	Towel	Household Object	Experimental Trial
1012	Cushion	Household Object	Experimental Trial
1013	Clothes hanger	Household Object	Experimental Trial
1014	Ladder	Household Object	Experimental Trial
1015	Hole puncher	Household Object	Experimental Trial
1017	Note pad	Household Object	Experimental Trial
1022	Scissors	Household Object	Experimental Trial
1030	Pliers	Household Object	Experimental Trial
1036	Sponge	Household Object	Experimental Trial
1060	Breadbasket	Household Object	Experimental Trial
1106	Red wallet	Household Object	Experimental Trial
1112	Hand shovel	Household Object	Experimental Trial
1129	Screw and nuts	Household Object	Experimental Trial
1131	Tape	Household Object	Experimental Trial

1132	Tape	Household Object	Experimental Trial
1135	Bucket	Household Object	Experimental Trial
1142	Stapler	Household Object	Experimental Trial
1143	Ball pen	Household Object	Experimental Trial
1149	Magnifying glass	Household Object	Experimental Trial
1198	Toilet tissue	Household Object	Experimental Trial
1200	Watering can	Household Object	Experimental Trial
1204	Bowl with open lid	Household Object	Experimental Trial
1208	Broom	Household Object	Practice Trial
1211	Water hose spray	Household Object	Practice Trial
1212	Bowl with lid	Household Object	Practice Trial
1213	Hand brush	Household Object	Experimental Trial
1214	Plastic container	Household Object	Practice Trial
1217	Clay pot	Household Object	Experimental Trial

1218	Chair	Household Object	Experimental Trial
1219	Chair	Household Object	Experimental Trial
1223	Wooden case	Household Object	Experimental Trial
1225	Pocket watch	Household Object	Practice Trial
1232	Candle	Household Object	Practice Trial
1235	Basket	Household Object	Experimental Trial
1237	Basket	Household Object	Experimental Trial
1240	Umbrella	Household Object	Experimental Trial
1247	Bunch of keys	Household Object	Experimental Trial
1249	Sponge	Household Object	Experimental Trial
1251	Paint brush	Household Object	Experimental Trial
1259	Cleaning supplies	Household Object	Experimental Trial
1261	Plastic container	Household Object	Experimental Trial
1262	Paint roller	Household Object	Experimental Trial
1267	Electric bulb	Household Object	Experimental Trial

1271	Drainer	Household Object	Experimental Trial
1273	Cabinet	Household Object	Experimental Trial
1274	Watering can	Household Object	Experimental Trial
1277	Candle	Household Object	Experimental Trial
1279	Candle	Household Object	Experimental Trial