Desire for Food and the Power of Mind

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In the Western world, overweight and obesity rates are high and continue to rise. Globally, 35% of adults are overweight, and 11% are obese (WHO, 2013). Obesity is related to many detrimental health consequences and a reduced quality of life (Jia & Lubetkin, 2005, 2010; Kolotkin, Meter, & Williams, 2001). Examples include cardiovascular diseases, diabetes, and psychological problems such as depression (e.g., Blaine, 2008; Luppino et al., 2010). Ultimately, the cause of obesity is an energy imbalance, that is, more calories are consumed than are expended (Westerterp, 2010). This energy imbalance seems mainly due to the overconsumption of high-caloric palatable foods (Swinburn, Jolley, Kremer, Salbe, & Ravussin, 2006; Swinburn et al., 2009; Westerterp, 2010). A more interesting question is *why* so many people have an unfavourable energy balance, which led them to be overweight, or even obese. So, why do so many people overconsume high-caloric palatable foods, while it is common knowledge that these foods are detrimental for your health and waistline?

An obvious possibility seems that people's control of homeostasis is disturbed (Gale, Castracane, & Mantzoros, 2004). However, at the very least, this homeostatic explanation is not sufficient, and non-homeostatic factors have been shown to play an important role (Shin, Zheng, & Berthoud, 2009). That is, people consume foods because of the expected experience of reward. Homeostatic and non-homeostatic factors may interact, as foods may for example become more attractive when one is hungry (e.g., Siep et al., 2009; Uher, Treasure, Heining, Brammer, & Campbell, 2006). So, an important contribution to the obesity epidemic likely is so-called hedonic hunger (Lowe & Butryn, 2007). That is, "some individuals experience frequent thoughts, feelings and urges about food in the absence of any short- or long-term energy deficit." (Lowe & Butryn, p. 432).

Desire for food is reflected in the brain as food-cue-elicited activity in brain regions that are involved in reward processing, as listed in Frankort et al. (2012, p. 627): "the amygdala, hippocampus, ventral pallidum, nucleus accumbens and striatum, the ventral tegmental area and substantia nigra, as well as the anterior cingulate, orbitofrontal, insular, posterior fusiform, dorsolateral prefrontal and medial prefrontal cortices (Berthoud, Lenard, & Shin, 2011; Kringelbach, 2009; van der Laan, de Ridder, Viergever, & Smeets, 2011)". With regard to the experience of desire, a highly relevant finding is that activity elicited by visual food stimuli in the insular cortex, the left operculum, and the right putamen, was modulated positively by the subjective feeling of appetite in lean healthy participants (Porubská, Veit, Preissl, Fritsche, & Birbaumer, 2006). Moreover, in a study in which participants were put on a monotonous diet and were asked during scanning to imagine sensory properties of a favorite food, craving-specific brain activity was found in the hippocampus, insula, and caudate (Pelchat, Johnson, Chan, Valdez, & Ragland, 2004).

With our Western environment being full of food temptations (e.g., Wadden, Brownell, & Foster, 2002), the experience of desire for food is always lurking. So, it has become a challenge to obtain or retain a healthy weight. However, the food-replete environment is not a problem for everyone, as an approximately equally large number of people have a healthy weight. Therefore, a reasonable hypothesis is that high caloric foods in the environment may be more attractive for certain people, making it harder for them to resist these foods, thereby possibly leading to overconsumption and ultimately to overweight or obesity.

From a cognitive perspective, this increased attractiveness is thought to be reflected in *biased* cognitive processing of food stimuli in people with overeating problems, such as overweight and obese people and high-restrained eaters. In other words, their desire for food may influence their cognitive processing of food stimuli, making it harder to resist these desires. Moreover, a biased cognitive processing of food stimuli may also maintain and/or further increase food desires. More specifically, their attention may be drawn preferentially to (high caloric) food cues (e.g., Werthmann et al., 2011), they may have more positive associations with (high caloric) foods (e.g., Roefs et al., 2011), and (high caloric) food cues may trigger more activity in the reward centers of their brains (e.g., Frankort et al., 2012). These cognitive processes all may contribute to the degree of experienced craving, desire, and thereby to food consumption.

Further adding to the potential power of high caloric food cues in the environment is the hypothesized *automaticity* of the increased cognitive hedonic reactivity to these food cues, while simultaneously assuming that cognitive resources are needed to activate the longer-term goal of a healthy weight (e.g., Hofmann, Friese, & Strack, 2009). As argued recently (Hofmann & van Dillen, 2012), these initial automatic responses can lead to habitual or impulsive eating behaviour, but they may also enter into working memory and can become a conscious desire, which may grow increasingly stronger (see also Kavanagh, Andrade, & May, 2005). If this desire escalates, conscious pursuit of the desire may follow, resulting in the consumption of the desired foods.

Taken together, the idea is that attention, associations and food-reward processing in the brain would all be *automatically* biased towards a *hedonic* response to food in susceptible people. This implies that people with overeating problems would show evidence of all three types of biased cognitive processing. But what is the current status of empirical evidence for this idea? Attention bias for food, implicit measures of associations with food, and brain reward activity in response to food cues will be considered successively in this chapter. The chapter will focus on research with people with overeating problems, that is overweight people and restrained eaters. Restrained eaters have a chronic intention to lose weight, but are frequently unsuccessful, and then indulge in the high caloric foods they attempt to avoid (Herman & Polivy, 1980, 2004). The frequent alternations between restraint and disinhibited eating may increase the attractiveness of the high-caloric foods that they actually consider as forbidden (e.g., Gendall & Joyce, 2001).

Biased Attention Towards Foods

A large number of studies have addressed biased attention towards food in various groups of people with eating problems: obesity and overweight, eating disorders, and restrained eating (see meta-analyses: Brooks, Prince, Stahl, Campbell, & Treasure, 2011; Dobson & Dozois, 2004). The hypothesized increased attractiveness of high-caloric foods in overweight people and high-restrained eaters is thought to be reflected in biased attention towards high caloric foods.

How is Attention Bias Measured?

Attention bias for food is frequently assessed using either a food variant of the emotional Stroop task (Williams, Mathews, & MacLeod, 1996) or with the visual probe paradigm (MacLeod, Mathews, & Tata, 1986) measuring response latencies and/or eye movements. In the food Stroop task, participants name the color of (different types of) foods words and neutral words. If participants are slower on the food word trials, it is concluded that the food words produce more interference, and this interference is often taken as evidence for an attention bias *toward* food. However, the interpretation of the emotional Stroop effect is not straightforward, as attentional *avoidance* of the stimulus altogether would also cause a slow-down in response latency (e.g., Field & Cox, 2008). Generally, the exact cognitive mechanism underlying the emotional Stroop effect is unclear (see Williams et al., 1996), which complicates the interpretation of interference scores.

The visual probe paradigm (e.g., MacLeod et al., 1986) is an improvement in that sense, as it can be clearly determined whether the participant shows relative attentional approach or avoidance as compared to a contrast category of stimuli. Typically, in this paradigm a pair of cues (e.g., one food and one neutral picture) is presented on screen, and after a certain interstimulus interval (ISI, e.g., 1000 ms), a dot replaces one of these pictures. The participant has to decide as quickly as possible in what location (typically left vs. right side of the screen) the dot appeared. If participants are on average faster on trials in which the dot replaces the food picture as compared to the neutral pictures, it is concluded that the participants have an attention bias towards food. A reverse effect is taken as evidence for attentional avoidance of food. If eye movements are measured, conclusions are reached in a similar way. It is tested whether a first eye movement more often goes to either the food or the control picture, and the gaze duration on both pictures is determined and compared.

Attention Bias for High Caloric Foods in Obesity and Restrained Eating

There is indeed some evidence for the idea that obese people preferentially attend (high-caloric) foods as compared to healthy-weight people. Using a visual probe task with eye tracking, Castellanos and colleagues (2009) found that sated obese participants, as compared to sated healthy-weight participants, preferentially attended to food as compared to neutral items, apparent both in initial orientation and gaze duration. No group differences were observed in the hungry state. Another study using the dot-probe task reported similar results: On a response latency based measure, obese people, but not healthy-weight controls, showed a bias toward food pictures, with the effect being primarily due to high-caloric foods (Kemps, Tiggemann, & Hollitt, 2014).

Partly converging evidence was found using event related potentials (ERP; Nijs, Franken, & Muris, 2010): Obese people showed evidence of an increased early attention bias toward high caloric food (reflected in P200 component), but no difference between obese and healthy-weight participants was seen on a later component (P300; see also Nijs, Franken, & Muris, 2008), or on a behavioral measure (response latency in Food Stroop paradigm). This pattern of results was partly observed in eye tracking data (Werthmann et al., 2011) as well: Obese people more frequently oriented towards a high caloric food picture than a neutral picture as compared to healthy-weight people, but their fixation duration on these food stimuli was shorter than in healthy-weight people, suggesting an approach-avoidance response in obese people. Taken together, the above three studies all found evidence for a relatively early attention bias toward food specifically in overweight or obese people, but diverged in their findings regarding later components of this attention bias (approach, no difference, or even avoid).

Partly in keeping with the previously discussed studies are the results from Nijs, Muris, Euser, and Franken (2010). They measured multiple indices of attention bias toward high caloric food (eye tracking - initial orientation and gaze duration, response latency in dot-probe task with 100 and 500 ms presentation of cue-pair, and P300). They only found an obese-healthy weight difference on their response latency data in the visual probe task with 100 ms cue-pair presentation, with obese people showing increased attention bias toward high-caloric foods. This partly fits with the above findings that the only difference between obese and healthy-weight participants was observed in an early component of attention bias. However, it is surprising that no differences were found in Nijs et al.'s (2010) eye-tracking data (cf. Werthmann et al., 2011, in which effects were only found in eye-tracking data, but not in response latency data).

Finally, on a food Stroop task, clear differences were observed between obese and healthy-weight children. That is, obese children specifically showed larger interference by food words than did healthy-weight children (Braet & Crombez, 2003). Note however that it is unclear how to exactly interpret results from this paradigm (see above). One cannot be certain whether increased interference actually reflects more or less attention towards the word itself.

So far it seems there is some evidence for an increased attention bias towards food in overweight and obese people, albeit most convincingly in relatively early attention processes. However, quite some studies, using various types of methodology, reported no relationship between BMI and attention bias for food: a dot-probe task comparing attention to healthy and unhealthy food words (Pothos, Tapper, & Calitri, 2009), comparing attention to food and neutral words with a very brief cue-pair presentation of 50 ms (Loeber et al., 2012), or comparing attention to high-caloric foods and neutral control stimuli in obese versus healthy-weight children (Werthmann, Roefs, Nederkoorn, Schyns, & Jansen, 2013a), an emotional Stroop task with healthy and unhealthy food words (Phelan et al., 2011; Pothos et al., 2009), and gaze time at high and low calorie foods in a free-viewing paradigm (Graham, Hoover, Ceballos, & Komogortsev, 2011). Finally, some studies even reported a reverse association between BMI and attention bias towards (high caloric) foods. That is, they found a reduced attention bias for these foods with increasing BMI. More specifically, Graham et al. (2011) found that their healthy-weight group oriented more frequently towards high caloric sweet foods than towards low-caloric foods, while they did not find differences in frequency of initial orientation between food types in their overweight group. In addition, in a visual search paradigm, participants showed increasingly faster detection of food compared to nonfood items with lower BMIs (Nummenmaa, Hietanen, Calvo, Hyönä, 2011). So, it is evidently too simplistic to conclude that obese people are characterized by an exceptionally strong attention bias towards high caloric foods.

Another group of people, who are hypothesized to be especially vulnerable to the tempting foods in our environment, are the restrained eaters. Whether this increased vulnerability to tempting food cues is reflected in biased attention towards food cues has been the topic of many studies, but again, it is hard to draw a general conclusion. Especially the food Stroop task has been employed frequently. Two meta-analyses (Brooks et al., 2011; Dobson & Dozois, 2004) conclude that there is a small food interference effect specifically in restrained eaters, but one meta-analysis (Johansson, Ghaderi, & Andersson, 2005) concludes that there are no differences between restrained and unrestrained eaters in this regard. Keep in mind the interpretation problems with the emotional Stroop task as well.

Using a visual probe paradigm, most studies found no evidence for a stronger attention bias toward food in restrained than unrestrained eaters (Ahern, Field, Yokum, Bohon, & Stice, 2010; Boon, Vogelzang, & Jansen, 2000; Brignell, Griffiths, Bradley, & Mogg, 2009; Werthmann et al., 2013b), whereas Hepworth, Mogg, Brignell, and Bradley (2010) did. Notably, using a free-viewing paradigm combined with eye-tracking a reverse effect was found. More specifically, restraint was associated with a reduced frequency of orientation to high calorie sweet foods in an overweight group (Graham et al., 2011).

So, taken together, there is no clear evidence for either attentional approach or attentional avoidance of (high caloric) foods in either overweight people or restrained eaters. Reaching a general conclusion over studies is complicated by the great diversity in paradigms, timing parameters, stimulus details, and comparison categories (e.g., high caloric vs. low caloric foods or foods vs. neutral items). Though the between-group approach did not prove to be particularly elucidating, what about studies that actually assessed craving for food and consumption of food?

Relationship Between Attention Bias and Craving and Consumption.

A highly relevant question as well obviously is whether an attention bias toward food is actually (causally) related to craving and food intake, as this is frequently assumed in studies assessing attention bias for food. However, it may also be argued that the attention bias toward food is caused by worry or anxiety about food. Relevant in this respect is that attention bias for food has also been frequently studied in anorexia nervosa patients. Clinically one could expect both worry/anxiety about food, and craving for food in this group of patients.

There have been quite some studies with the food Stroop task in Anorexia Nervosa (AN) patients, but a meta-analysis (Dobson & Dozois, 2004) concluded that the food interference effect was not consistently observed in AN patients. In a study using the visual probe paradigm, an attention bias toward high caloric foods was observed (Shafran et al., 2007), and in another study, increased distraction by high caloric and low caloric foods was observed in AN patients (Smeets, Roefs, van Furth, & Jansen, 2008). Note that exactly the reverse, that is, reduced attention for food stimuli in AN patients was observed in a recent eye tracking study (Giel et al., 2011). So, again, research with an individual differences approach is not particularly elucidating, and the overall picture is not very consistent. Therefore, research that actually measures craving, or studies in which either craving or attention bias is manipulated, may help us further.

Correlations have been observed between attention bias toward food and momentary craving in an overweight group but not a healthy-weight group (Werthmann et al., 2011), and between attention bias toward chocolate and chronic chocolate craving (Kemps & Tiggeman, 2009; Smeets, Roefs, & Jansen, 2009; Werthmann, Roefs, Nederkoorn, & Jansen, 2013c). Supporting the association between attentional processing and the control of craving, a recent ERP-study (Harris, Hare, & Rangel, 2013) found evidence for early attentional modulation by successful versus unsuccessful self-control, but only when weight-loss was made relevant for the participants by monetary incentive. More specifically, on trials on which participants made a food choice indicative of unsuccessful self-control (e.g., chose an unhealthy liked food), the N1 amplitude was more negative (reflecting more attentive processing) than on trials on which participants made a food choice indicative of successful self-control (e.g., chose a healthy but disliked food). So, successful self-control in the context of food choice was associated with attention suppression.

In addition, there is also evidence for a causal relationship, that is evidence that induced craving for chocolate leads to an attention bias for chocolate in chocolate likers (Kemps & Tiggeman, 2009) and high trait chocolate cravers (Smeets et al., 2009). Relatedly, it was observed that attention bias toward a food decreased from a pre-measure (before the food was eaten to satiety) to a post-measure (after the food was eaten to satiety) (Di Pellegrino, Magarelli, & Mengarelli, 2011).

Interestingly, there is also evidence for a causal relation in the other direction, with manipulated attention for food affecting craving and/or food intake. More specifically, in two experiments (Kemps, Tiggemann, Orr, & Grear, 2013) it was shown that participants who were trained to attend to chocolate cues, consumed more chocolate in a so-called taste test afterwards as compared to participants who were trained to avoid chocolate cues. Moreover, in one of these experiments (but not the other), the attend-chocolate training was associated with an increase in craving whereas the avoid-chocolate training was associated with a decrease in craving. Similar results were obtained in a study in which participants were either trained to attend to healthy or to unhealthy foods. It was found that participants who were trained to attend to healthy foods consumed relatively more healthy than unhealthy foods afterwards, as compared to the participants who were trained to attend to unhealthy foods (Kakoschke, Kemps & Tiggeman, 2013). Note that in both Kemps et al. (2013) and in Kakoschke et al. (2013), the training procedure also successfully altered the attention bias for the targeted food. This was corroborated in a later study, in which it was also found that an attentional training procedure changed the attentional bias, both on the dot-probe task and on a word-stem completion task (Kemps et al., 2014).

Using a novel attention bias modification procedure, based on the anti-saccade task (e.g., Hallett, 1978), converging evidence was obtained (Werthmann, Field, Roefs, Nederkoorn, & Jansen, 2014). Here it was found that participants who were trained to avoid looking at chocolate and who performed highly accurately during the training, showed a reduced chocolate intake as compared to a group of participants who were trained to look towards chocolate. No effects of the training on craving were observed though. In stark contrast to these three studies are results from a study that manipulated attention bias towards cake. Only weak evidence was found for change in the attention bias itself, and no effects on hunger or food intake were found (Hardman, Rogers, Etchells, Housoun, & Munafò, 2013).

Taken together, there is a substantial amount of evidence for an association between biased attention for food and craving for food, with even some evidence in support of a causal relationship between these two variables. This conclusion is in line with the results from a meta-analysis on the association between attention bias and craving for addictive substances (Field, Munafò, & Franken, 2009). In this meta-analysis, the association between attention bias and craving was small but significant, with some indications for a larger correlation when the measure that was used reflected attentional disengagement. Importantly, the correlation was substantially higher for studies employing a direct measure of attention bias (i.e., eye movement monitoring and ERP measurements) as compared to indirect response latency based measures.

Top-down Influences on Attention bias

As partly reviewed above, there is quite a large literature on individual differences in attention bias toward (high caloric) foods, the hypothesis under investigation being that overweight/obese people and chronically restrained eaters show attentional approach toward these foods. The findings have been disappointingly inconsistent. Part of the problem of course is the huge diversity in employed paradigms, stimuli, and timing parameters, compromising the comparability across studies.

A more general problem is the double-facetted nature of high-caloric foods. The investigated groups, in daily life, typically fluctuate frequently between a momentary focus on taste versus a focus on health/weight consequences, reflecting this double-facetted nature of high caloric foods. These fluctuations may be especially pronounced for people with weight problems. The possibility that attention focus (i.e., focus on taste of food versus focus on healthiness of food) is an overlooked factor with the potential to explain the divergence of findings in the field is rather unexplored. It may be the case that such a momentary focus is a stronger determinant of attention bias for food than are more stable individual differences in weight and restraint status.

One hint that this may be the case is provided by studies that induced craving for food or an addictive substance. The induction of craving possibly led to a strong focus on taste or reward at the cost of health considerations. Indeed, inducing craving for chocolate led to an attention bias toward chocolate in two studies (Kemps & Tiggeman, 2009; Smeets et al., 2009). Relatedly, Werthmann et al. (2013c) found an association between self-endorsed eating permission, that is, whether participants reported that they allowed themselves to consume chocolate in a taste-test of the experiment, and a relatively long dwell-time on chocolate. Similarly, using eye-tracking methodology as well, it was found that an attention bias for rewarding stimuli was enlarged when participants expected to receive these rewards (Jones et al., 2012). Relevant here as well is that an attentional bias for food was completely eliminated by providing participants with a concurrent high cognitive load, suggesting that some resources are necessary to recognize temptations (Van Dillen, Papies, & Hofmann, 2013).

In addition, from the meta-analysis by Field and colleagues (2009), it became apparent that the correlation between attention bias toward addictive substances and craving for these substances was particularly large when craving was induced in participants as compared to no-craving-induction control conditions. The craving induction possibly had the effect that all participants were focused on the same aspect of the addictive substance, the positive rewarding aspect. So, the participants may have alternated less between focus on positive versus negative consequences of the addictive substance, leading to a higher correlation between attention bias and craving.

Also supporting the relevance of attention focus is an ERP study (Meule, Kübler, & Blechert, 2013) in which participants were asked to focus either on the immediate or on the long-term consequences of consuming high caloric and low caloric foods. The late positive potential (LPP), which is thought to be driven by arousal (Olofsson, Nordin, Sequeira, & Polich, 2008, in Meule et al., 2013), was sensitive to the immediate versus long-term manipulation. More specifically, the LPP was most positive when participants focused on the long-term consequences of high caloric food consumption, which the authors interpreted to reflect negative arousal. In a similar vein, the LPP was modulated by a food availability manipulation. That is, restrained eaters, but not unrestrained eaters, showed a less positive LPP for available than for unavailable food cues, which according to the authors might reflect a down-regulation of reactivity to available food stimuli, in order to adhere to their diet later.

In addition, a line of research that focuses on the malleability of attention biases in general, supports top-down influences as well. Both in an emotional Stroop task and in a dot-probe task, an attention bias toward negative stimuli was only observed when participants were required to focus on the affective stimulus information, but not when they were required to focus on the non-affective semantic stimulus information (Everaert, Spruyt, & De Houwer, 2013). This suggests that the way stimuli are processed (i.e. top down influences: focus on affect versus focus on semantics) determine the attention bias. Similarly, in a dot-probe paradigm it was shown that attention was biased toward stimuli reflecting a prioritized goal (Experiment 1) or a goal with a high expectancy of success (Experiment 2) (Vogt, De Houwer, & Crombez, 2011).

Taken together, the double-facetted nature of high-caloric foods, that is, their high caloric value being a threat to a healthy BMI on the one hand and their high palatability on the other hand, may be part of the explanation for the great diversity of research findings in this field. The attention focus (health versus taste) may fluctuate within participants across and within studies, making it more difficult to observe consistent individual differences. Characteristics of the paradigm (e.g., pitting high caloric foods against low caloric foods versus pitting high caloric foods against a neutral category) may inadvertently elicit either an increased focus on health or on palatability, and thereby may affect the observed group differences.

Currently it is unclear whether craving and food-related worry/anxiety are related to attention bias for high caloric foods in a similar way. That is, are they both related to attention approach, or is craving related to attention approach and food-related worry/anxiety related to attention avoidance. This cannot be inferred from studies employing an individual differences approach as it is unclear what attention focus the participants had while performing most studies, and the observed group differences go in multiple directions. In obese as well as restrained eaters both types of attention focus are possibly equally likely.

Moreover, the study of attention bias may be considered a quantitative approach, in the sense that one can only conclude whether a participant pays *more* or *less* attention to (high caloric) foods as compared to neutral non-food or low-caloric food stimuli. That is, this approach does not inform us to what feature of the food the participant pays attention. Is attention captured by the high caloric content's negative BMI consequences or by the high palatability? Maybe the attention bias depends on stimulus relevance (Broeren & Lester, 2013), without distinguishing between positive versus negative valence. If the attention bias happened to be driven by craving, then one observes the expected correlations with craving and possibly the expected group differences. If the attention bias happened to be driven by food-related worry/anxiety, then no correlations with craving would be observed, and possibly group differences go in a different direction.

Implicit Measures of Associations with Food

A related field of research is focused on the positive versus negative associations that are triggered by different types of food. Quite a number of studies have obtained so-called implicit measures of associations with food in obese/overweight people and high-restrained eaters. Before briefly explaining the paradigms that are used to obtain these measures, it is important to specify what the term 'implicit' means. De Houwer, Teige-Mocigemba, Spruyt, and Moors (2009) defined an *implicit* measure as "a measurement *outcome* that is causally produced by the to-be-measured attribute in the absence of certain goals, awareness, substantial cognitive resources, or substantial time" (p. 350). It is important to keep in mind that implicitness is not an all-or-none feature of a measure (Moors & De Houwer, 2006), and in what sense implicit measures of associations can be considered implicit is heavily debated (De Houwer et al., 2009; Roefs, Huijding, Smulders, Jansen, & MacLeod, in press), and is beyond the scope of the current chapter. It suffices for now that these implicit measures are generally obtained with the goal to circumvent the problems associated with direct self-reports (i.e., reliance on introspection). The implicit measures (i.e. measurement outcomes) are obtained by indirect measurement procedures such as the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) and the Affective Priming Paradigm (APP; Fazio, Sanbonmatsu, Powell, & Kardes, 1986). Indirect means that the participants are not directly asked to report on their associations, but their associations are inferred from their behaviour, their pattern of response latencies in the computer task. This pattern of latencies is considered informative regarding associations people have with for example high caloric foods.

Measurement Procedures

In the APP (Fazio et al., 1986), two stimuli are presented in quick succession: a prime followed by a target. In food research the primes are typically different types of foods and the targets general positive and negative stimuli. The prime is briefly presented and can be ignored by the participant. The target is then presented and the participant is required to evaluate it as quickly as possible. The logic of the paradigm is that affectively congruent prime-target pairs (e.g., strawberry-paradise) should lead to shorter response latencies than affectively incongruent prime-target pairs (e.g., strawberry-disaster). The extent to which this pattern of response latencies is indeed observed, reflects the person's evaluation of the prime (e.g., strawberry).

In the IAT (Greenwald et al., 1998), the participant is asked to categorize each presented stimulus as quickly as possible, either according to a target dimension (e.g., high caloric versus low caloric foods) or an attribute dimension (e.g., positive versus negative). In the two critical phases of the task these dimensions are combined. That is, targets (i.e. high-caloric and low-caloric foods) and attributes (positive and negative adjectives) are presented in an alternating random order. In a first critical phase, the target category 'high-caloric food' and attribute category 'positive' share a response key, as well as the target category 'low-caloric food' and attribute category 'negative'. So, participants press the same key if a high-caloric food item or a positive attribute is presented, and press the other key if a low-caloric food item or a negative attribute is presented. In a second critical phase these combinations are reversed, such that 'high-caloric food' and 'negative' now share a response key, as well as the categories 'low-caloric food' and 'positive'. The IAT effect is computed by taking a difference score between these two critical phases, with the logic being that participants perform faster if associated categories share a response-key than when non-associated keys share a response key. So, in the current example, if participants are faster in the first critical phase than in the second critical phase, this is taken as evidence for a preference for high-caloric foods over low-caloric foods.

Group differences in Food Associations in Obesity and Restrained Eating

According to the hypothesis of increased positive hedonic reactivity, it was expected that overweight people and restrained eaters' implicit measures of associations with food would be positive. That is, that overweight people and restrained eaters would have more positive associations with high-caloric than with low-caloric foods, as compared to healthy weight people and unrestrained eaters. The empirical evidence mostly goes in exactly the opposite direction though.

On IAT-measures, obese (Roefs & Jansen, 2002) as well as restrained eaters (Vartanian, Polivy, & Herman, 2004) had more negative associations with high-caloric foods than with low-caloric foods as compared to healthy-weight people and unrestrained eaters respectively. In addition, using the APP, it was found that all participants, regardless of BMI, preferred low-caloric palatable foods to high-caloric palatable foods (Roefs et al., 2005). In a similar vein, Werrij et al. (2009) found that obese as well as healthy-weight people associated palatable high caloric foods more with restraint than with disinhibition. Obese children are no exception in this respect, as it was observed that obese and lean children alike had more positive association with healthy than with unhealthy foods (Craeynest, Crombez, Haerens, & De Bourdeaudhuij, 2007).

Top-down Influences on Implicit Measures of Associations with Food

Importantly, the studies reviewed above all share a methodological characteristic: high-caloric foods are compared to low-caloric foods within the same task, which may elicit an attention focus on the health-consequences of high-caloric foods. Houben, Roefs, and Jansen (2010) addressed this possibility using variants of the IAT. In their first experiment high and low-restrained eaters both showed more negative associations with high-caloric than low-caloric foods, in the absence of positive associations with high caloric foods, which is in line with earlier work. In their second experiment they tested positive and negative associations with only high-caloric foods. In this experiment they did find that high-restrained eaters showed more positive associations with high-caloric foods than did low-restrained eaters. The absence of the low-caloric food alternative may have led to an attention focus on palatability.

Roefs et al. (2006) more directly tested the role of attention focus on associations with high-caloric and low-caloric foods using an APP. They found that manipulated attention focus (palatability versus health) influenced the observed associations with the food stimuli in the expected way. More specifically, when focused on palatability, participants showed more positive associations with high-caloric and palatable food, whereas they showed more positive associations with low-caloric and unpalatable food when they were focused on health. So, this implicit measure of associations with food was influenced by a manipulation of attention focus, rather than by weight status (obese versus healthy weight).

Taken together, also for implicit measures of associations with food it may be too simplistic to just study group differences such as overweight versus healthy weight people or high versus low restrained eaters. Even though these implicit measures are considered to reflect relatively fast processes, these too are likely influenced by top-down influences. That is, it matters which aspect of the double-facetted nature of high-caloric foods is in focus: palatability or health/weight consequences. The final part of this chapter is concerned with brain-imaging studies that measured neural activation in reward-related areas of the brain in response to visual food stimuli.

Reward Processing in the Brain

The last decade has witnessed a large number of functional Magnetic Resonance Imaging (fMRI) studies addressing activity in reward-related areas of the brain in response to different types of food cues, and comparing obese/overweight and healthy weight people. Again, the general hypothesis is that obese people would be characterized by stronger hedonic reactivity to (high caloric) food cues. The dependent measure in these studies is the so-called blood oxygen level dependent response of the brain (BOLD response), with the logic being that active brain regions require more oxygen, and oxygen-rich blood has different magnetic properties than does oxygen-poor blood.

Food Reward Processing in the Brain in Obesity and Restrained Eating

Indeed, research findings indicated that obese and overweight participants showed a greater BOLD response to visual food stimuli in several reward-related areas of the brain than did healthy-weight participants (e.g., Bruce et al., 2010; Martin et al., 2010; Rothermund et al., 2007; Stoeckel et al., 2008). Only a few fMRI studies have compared high and low restrained eaters (Coletta et al., 2009; Schur et al., 2012), and they also found evidence for group-differences in brain reward activity, which were modulated by hunger state (Coletta et al., 2009) and the provision of a preload (Schur et al., 2012).

Importantly, though these studies observed differences in several reward-related areas of the brain (e.g., amygdala, insula, striatum, orbitofrontal cortex), the exact areas in which group differences were observed varied considerably over studies. Highly relevant in this respect is a meta-analysis conducted on studies on the neural correlates of processing visual food cues in healthy-weight participants, using a whole-brain approach (van der Laan et al., 2011). The results were remarkable, in the sense that at best 41% concurrence over studies was observed. The three areas that most consistently showed an increased BOLD response to food versus neutral cues included the lateral occipital complex, the left lateral orbitofrontal cortex, and the insula. A similar lack of consistency was apparent in a meta-analysis of fMRI studies including overweight and healthy-weight participants (Brooks, Cedernaes, & Schiöth, 2013).

Top-down Influences on Reward Processing in the Brain

Of course several methodological reasons can be mentioned that may explain the limited concurrence over studies, such as: small *n*, technical differences (i.e., different scanners), design choices (i.e., blocked versus event-related presentation of stimuli), etc. But another important point to consider again is the attention focus of the participants. In many of these studies, participants generally had no other task than to simply pay attention to the presented stimuli, giving no control over what participant actually cognitively do with these food stimuli. As in other types of research, the attention focus of participants likely varies within and across participants, and within and across studies. There is likely a lot of fluctuation between a focus on the palatability of the foods on the one hand and the negative consequences of the high caloric value on the other hand.

The role of attention focus in this type of studies has been addressed recently. Frankort and colleagues (2012) had overweight and healthy-weight participants focus on the palatability of the presented visual food stimuli in half of the runs (biased viewing: focus on palatability), provided no such prime in the other half of runs (unbiased viewing), and compared patterns of BOLD. The overweight sample showed increased activity in reward-related brain areas, but only when focus was on palatability. Strikingly, the group difference was reversed in the unbiased viewing condition: it was the healthy-weight sample that showed increased activation of the reward system. In addition, Siep and colleagues (2009) showed that food cue related activity in the amygdala and medial orbitofrontal cortex critically depended on the explicit evaluation of the palatability of the foods.

In a similar vein, Siep and colleagues (2012) showed that activity in important regions of the mesocorticolimbic circuitry was influenced by the specific instructions provided to participants regarding their processing task for the presented food stimuli. Generally, this activity was enhanced when participants were instructed to up-regulate food palatability thoughts, but diminished when participants were instructed to suppress these thoughts and cravings. In line with these findings, Giuliani and colleagues (Giuliani, Calcott, & Berkman, 2013) showed that cognitive reappraisal with the goal of reducing food desires indeed caused a reduction in self-reported desirability of food. A later study from this lab (Giuliani, Mann, Tomiyama, & Berkman, 2014) found that this type of cognitive reappraisal caused activation in top-down self-regulation brain regions (e.g., dorsolateral prefrontal cortex), which is in line with findings of an earlier study that investigated the effect of cognitive control of food desire on brain activation (Hollmann et al., 2012).

Moreover, a manipulation of mindset (focus on health vs. focus on taste) modulated value (taste and health ratings) related neural activity (Bhanji & Beer, 2012), and the provision of health cues with the visual presentation of food cues modulated value signals in ventromedial prefrontal cortex (Hare, Malmaud, & Rangel, 2011). In sum, activity in reward-regions of the brain appears differentially impacted not only by physical characteristics (e.g., body weight), but also by cognitive factors like attention focus (e.g., focus on palatability) and processing goals (e.g., upregulation vs. suppression).

Conclusion: the Power of Mind

Taking all three discussed lines of research into consideration, that is attention bias toward high caloric foods, implicit measures of association with high caloric foods, and food-cue elicited activity in reward processing related areas of the brain, it seems fair to conclude that top-down processes may play an important role, which has not been sufficiently studied yet. High caloric foods have a double-facetted nature, of which many people are aware. They represent on the one hand highly palatable foods to indulge in, and on the other hand represent a threat to one's waistline. So, top-down processes may influence the way one conceptualizes a food stimulus, which in turn may determine further cognitive processing and ultimately behaviour.

Even when obtaining measures that are considered to be relatively automatic (e.g., attention bias and implicit measures of associations), no clear consistent evidence was obtained for increased hedonic reactivity to high-caloric food cues in obese/overweight people or high restrained eaters. So, even at this relatively early stage of cognitive processing, top-down influences of attention focus may already bias our perception, attention, and our associations, which speaks against a strictly serial model of increasingly complex cognitive processing.

So, obese/overweight people and restrained eaters are not necessarily always ‘plagued’ by hedonically driven associations and cognitive biases. Instead, top-down processes may determine whether cognitive biases are driven by hedonics or health-concerns, even when measures are considered implicit. As a consequence, it is likely too simplistic to just study individual difference, that is compare for example obese/overweight people and healthy weight controls, or high and low restrained eaters. The attention focus likely shifts frequently between palatability and health, both within and across people, and within and across studies, making it difficult to observe clear group differences.

How to curb problematic desire for food?

One approach to reducing food desires is by targeting the behavioral impulses that are evoked upon encountering palatable food cues. Though obese people are not necessarily always plagued by hedonic reactivity when confronted with high-caloric food cues as argued above, their attention focus will at least for a substantial amount of time be set on hedonics. So, targeting these behavioral impulses could be a viable approach.

Previous endeavors to decrease food desire and overweight by training general inhibition abilities however showed disappointing results. For instance, food intake was higher following impulsivity induction compared to inhibition induction, but this effect was mainly due to increased food intake in the impulsivity condition, while general inhibition training was unsuccessful in reducing food intake (Guerrieri, Nederkoorn, & Jansen, 2012). Recent efforts in inhibitory control training specifically for food show more promising results. Specifically, these lines of research suggest that impulses triggered by palatable food can be reduced by pairing such cues with behavioral stop signals in a go/no-go task. Work from different laboratories has found that consistently withholding responses to palatable food cues is effective in reducing choice for palatable food (Veling, Aarts, & Stroebe, 2013), consumption of palatable food (Houben, 2011; Houben & Jansen, 2011; Veling, Aarts, & Papies, 2011), and body weight (Veling, van Koningsbruggen, Aarts, & Stroebe, 2014) relative to control conditions in which participants are allowed to respond to palatable food cues.

Other cognitive behavioural approaches include ‘attention-retraining’, as discussed earlier in this chapter, and food-cue exposure with response prevention. Food-cue exposure with response prevention is based on principles of Pavlovian conditioning, and consists of a prolonged exposure to food cues (i.e., intense smelling of the foods, etc.) while actual eating is not allowed, with the goal of breaking the bond between the conditioned stimulus (food cues) and the unconditioned stimulus (actual eating) (Jansen, 1994).

Some studies on attention-retraining indeed provided promising results, in that training attention away from unhealthy foods, actually led to a decrease in food consumption afterwards (e.g., Kakoschke et al., 2013; Werthmann et al., 2014), whereas others were not successful (Hardman et al., 2013). For food-cue exposure with response-prevention, some small-scale studies with promising results have been published. That is, cue-exposure with response prevention successfully extinguished binges in bulimic patients, with effects sustained at 1-year follow up (Jansen, Broekmate, & Heymans, 1992), and reduced binges and eating in the absence of hunger in children (Boutelle et al., 2011). Moreover, recently, in a neuroimaging study (Frankort et al. 2013), it was found that prolonged exposure to chocolate, led to extinction on a neural level, without a parallel extinction on a self-report level. So, the extinction of the neural response in reward-related areas of the brain may precede the self-reported extinction of craving for chocolate.

Taken together, treatments targeted at increasing inhibition or self-control, or reducing food desires may be helpful. Initial results certainly are promising, but more research is needed to learn what types of training to reduce food desire and to increase inhibition are most effective. Interesting in this respect is that successful post-obese dieters showed reduced cue-reactivity, that is, a reduced salivation response to food cues, as compared to currently obese participants (Jansen, Stegerman, Roefs, Nederkoorn, & Havermans, 2010). So, successful weight loss seems to go hand in hand with reduced cue-reactivity. Moreover, a neuroimaging study showed that successful weight-loss maintainers showed more activity in response to food-cues in brain regions associated with inhibition as compared to obese and healthy-weight controls (McCaffery et al., 2009).

Finally, in line with the proposed importance of an attentional focus on either hedonics or health, as argued in the current chapter, a treatment focused on changing the attentional focus could also be an option worth exploring. One could argue that frequent reminders would be necessary to keep people's attentional focus set on health. One possibility may be the use of eHealth, in which treatment delivery is automated via smartphones for example. This allows frequent and enduring intervention, at the times it matters most, that is, in the eating situation.

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