Focus on food

Summary

Our current society is characterized by conflicting views on food. One the one hand, food enjoyment is viewed as highly desirable but on the other hand, a thin body shape is idealized. The modern food environment presents an overabundance of highly palatable, high-caloric, cheap, and easily accessible food (Hill & Peters, 1998; Morland & Evenson, 2009; Townshend & Lake, 2017). As a result, the prevalence of obesity is rapidly increasing (Berghofer et al., 2008; Flegal, Carroll, Ogden, & Curtin, 2010; WHO, 2020). This represents a problematic development, as obesity is associated with numerous detrimental health outcomes, such as diabetes and heart disease (Finkelstein, Ruhm, & Kosa, 2005; WHO, 2020). In this obesogenic environment, many people engage in chronic dietary restraint, that is, they constantly monitor their food intake to try to limit their food intake to control their body weight (Herman & Polivy, 1980). Restrained eaters might be particularly torn between the conflicting aspects of high-caloric palatable food (Stroebe, Van Koningsbruggen, Papies, & Aarts, 2013). The conflicting aspects of food are likely reflected in a person's mindset with respect to food (Werthmann, Jansen, & Roefs, 2016). People can be in a hedonic mindset, in which they likely focus on pleasure derived from food. Alternatively, people can be in a health mindset in which they likely focus on health-related aspects of food consumption. Restrained eaters might be particularly prone to fluctuate between these mindsets (Werthmann et al., 2016). However, food perception may generally be influenced by the current state of the individual. Also, other factors, like hunger, likely influence the way an individual reacts to food (cf., Hardman et al., 2021). The current thesis assessed effects of mindset and hunger (state factors) and dietary restraint (trait factor) on brain responses to food, attention bias (AB) for food and food intake.

Chapter 1 provides a general introduction to the topics of this dissertation. It discusses the inconsistent literature on brain responses to food in restrained eaters (Roefs, Franssen, & Jansen, 2018; Werthmann, Jansen, & Roefs, 2015). Furthermore, it highlights the double-sided nature of high-caloric food. That is, high-caloric food has a high hedonic value, because its consumption is pleasurable, but a low-health value, because it promotes weight gain. It proposes that considering the double-sided nature of high-caloric food by

taking mindset into account will help in resolving the inconsistencies (Roefs et al., 2018). In addition, this chapter discusses the inconsistent literature on AB for food in restrained eaters, and suggests that current states (mindset, hunger) play a role in AB for food, and need to be considered to resolve the inconsistencies. Finally, the aim and main hypotheses are introduced. In short, we expected that brain responses in the mesocorticolimbic system would be highest in response to high-caloric palatable food, particularly in a hedonic attentional focus. We expected that attentional focus dependent differences in brain responses to food would be most marked in participants with high levels of dietary restraint. Furthermore, we hypothesized that AB for food would be stronger and food intake would be higher in a hedonic than in a health mindset, and that effects of mindset would be most noticeably in participants with high levels of dietary restraint. In addition, we expected an increased AB for food in participants with high levels of dietary restraint, especially in a hungry state.

In chapter 2, we investigated if attentional focus and dietary restraint influence brain responses to foods that varied in both caloric content and palatability. To this end, we conducted a functional magnetic resonance imaging (fMRI) study in which female participants with varying levels of dietary restraint were presented with individually tailored palatable and unpalatable, high-caloric and low-caloric food pictures. In each participant, we induced three attentional foci (hedonic, health, and neutral) with a fast-paced one-back task. We analyzed the results using mass-univariate analysis techniques, in which a separate analysis at each voxel is conducted, and average brain activity level is assessed, as well as using multi-voxel pattern analysis (MVPA) in which patterns of brain activity across multiple voxels are assessed. We observed only small differences in activity level between high-caloric and low-caloric food. We also observed no differences in brain activity level between palatable and unpalatable food. These results were also supported by Bayesian analyses which showed mostly evidence in favor of the null hypothesis (no differences in brain activity level between palatable and unpalatable food stimuli; no differences in brain activity level between high-caloric and low-caloric food stimuli). Instead, brain activity level was strongly influenced by attentional focus. We observed 28 cluster

with significantly different activity level between the three attentional foci. Most regions belonging to the mesocorticolimbic system, which is considered as the brains' reward system, responded most strongly in the hedonic attentional focus. Brain activity level did not depend on dietary restraint. Palatability and calorie content could be decoded using MVPA, but decoding performance did not depend on attentional focus and was not correlated with dietary restraint. These results suggest that the level of brain activity does not reflect the rewarding value of food, because brain activity level did not differ between palatable stimuli, which are highly rewarding, and unpalatable stimuli, which are not rewarding at all. Both, palatable and unpalatable food stimuli are highly salient (cf., Kahnt, 2018; Kahnt & Tobler, 2017), and food in general will be most salient when hedonic aspects are considered. So, the current results suggest that the level of brain activity could reflect the salience of food. This suggests that the theory, which states that increased brain activity level in response to food reflects the increased reward value of food is inaccurate, because this theory predicts differential activity levels between palatable and unpalatable food stimuli (cf., Roefs et al., 2018). Food characteristics, like palatable and calorie content, are not reflected in the level of brain activity but instead in multi-voxel patterns of brain activity.

In chapter 3, we investigated if mindset and dietary restraint affect AB for food and food intake. Therefore, we had female students with varying levels of dietary restraint perform a visual search task during which eye-movements and response latencies were recorded. In the visual search task, participants had to locate a target stimulus and indicate its identity while food and neutral distractors, which must be ignored, appeared on the display. Mindset was manipulated with short video clips that either portrayed appetizing food and people enjoying food to induce a hedonic mindset, or healthy food and people exercising to induce a health mindset. Food intake was measured during a bogus taste test, in which participants were required to taste different types of high-caloric snack foods and rate their taste, while the amount of food consumed was covertly measured. We observed that the neutral distractor tended to be fixated more often than the food distractor. So, if anything, participants focused their attention

away from food. However, we observed no effects of mindset and dietary restraint on eye-movements or reaction times. Similarly, we observed no effects of mindset on food intake, but we observed that participants with higher dietary restraint scores tended to consume more food during the bogus taste test. We also observed that manual response latency-based AB for food and food intake tended to correlate positively, but only in the hedonic mindset. So, the current results suggest that restrained eaters are not characterized by an increased AB for food, but that they might be more prone to overconsumption of food, nonetheless.

In chapter 4, we assessed if hunger and dietary restraint influence AB for food and food intake. To this end, we recruited female restrained eaters and asked them to perform a visual search task, in which we measured reaction times. During the visual search task, participants were presented with matrices consisting of words. Matrices either consisted of neutral words with one food words, or food words with one neutral word. Food intake was assessed during a bogus taste test, in which participants were asked to taste and rate high-caloric and low-caloric snack foods, while we secretly measured how much food participants consumed. In the visual search task, we observed that participants with high levels of dietary restraint were faster especially at detecting low-caloric food than participants with low levels of dietary restraint. Participants with low levels of dietary restraint were generally more distracted by food than participants with high levels of dietary restraint. During the taste test, we observed that participants consumed more calories from high-caloric food when fasted than when satiated, whereas there was no significant difference in calories consumed from low-caloric food between fasted and satiated states. In addition, participants with high levels of dietary restraint tended to consume more food when satiated. AB for food tended to correlate with intake of low-caloric food. These results also suggest that restrained eaters are not characterized by an AB for food, but might have the tendency to overeat.

Chapter 5 provides a summary and discussion of the main findings and conclusions of the current dissertation and presented suggestions for future research. In brief, the results of the current thesis suggest that the level of brain activity does not reflect palatability and barely reflects calorie content of

food. This indicates that the level of brain activity does not reflect the reward value of food. Instead, the level of brain activity was strongly influenced by attentional focus, with the highest level of brain activity being detected in the hedonic attentional focus, in which food is likely highly salient. So, it seems that the level of brain activity in response to food reflects motivational salience instead of reward value of food. This suggests that dominant theory, which suggests that increased level of brain activity in the mesocorticolimbic system in response to food reflects the reward value of food, is flawed, because this theory predicts differences in brain activity level highly palatable and unpalatable food stimuli (cf., Roefs et al., 2018). Instead, palatability and calorie content of food items are reflected in multi-voxel patterns of brain activity. Brain responses to food were also not related to dietary restraint, suggesting that the current mental state is more influential on brain responses to food. Effects of attentional focus might have gone unnoticed in previous studies, as attentional focus has rarely been considered. Furthermore, dietary restraint was not related to an increased AB for (high-caloric) food. Considering the overall inconsistent results in the literature (Werthmann et al., 2015), it seems that AB for food might not underlie craving in restrained eaters. One might need to investigate other factors to explain the conflicted food approach of restrained eaters. Also, mindset and hunger did not influence AB for food, and might be less influential on AB for food than expected. Altogether, the current results underline the importance of a clear mental task when studying brain responses to food, and suggest that AB for food is not a crucial factor in conflicted food motivation in restrained eaters.