The effect of hunger status and weight on the preference of food.

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Abstract

Obesity has become a global problem. One of the most important factors contributing to obesity is eating in the absence of hunger. Eating in the absence of hunger in obese individuals may be caused by an unchanged preference for high-energy foods. The objective of this study was to investigate the effect of hunger/satiation and weight on the preference of food. 136 participants did an online task rating food images on preference. In a sub experiment, 27 participants did the rating task in two conditions; hungry and satiated. Results showed an interaction effect of hunger status and weight on the preference of food. The difference in preference ratings between hunger and satiety is higher in the lighter-weight people and there is only a small difference in preference between hunger and satiety in the heavier-weight people. The sub experiment showed an effect of hunger status on preference. Furthermore, there was an interaction effect of weight and energy content on preference. Results of this study suggest that both hunger status and weight play an important role in food preference. This could be used to develop a new strategy for reducing and preventing obesity.

Introduction

Obesity has become a global problem (James, 2004; McLellan, 2002; Swinburn et al., 2011). In the Netherlands alone, 50.3% of people 20 years and over are overweight, of which 13.7% are obese (CBS, 2015). Overweight and obesity can lead to a number of health problems, for example diabetes, hypertension and coronary heart disease, which lead to higher health costs (James, 2004). One of the causes for this epidemic is an environment that promotes excessive eating and large portion sizes (Faith et al., 2006; Fisher & Birch, 2002; Hill & Peters, 1998). There are different factors that contribute to obesity, such as genetic traits, diet and lack of physical activity (Weinsier, Hunter, Heini, Goran, & Sell, 1998). One of the most important factors is eating in the absence of hunger (Shomaker et al., 2010; Birch, Fisher, & Davison, 2003; Fisher & Birch, 1999). In other words, this disinhibited eating occurs not in response to factors such as hunger and satiety, but to other factors such as the presence and smell of palatable food or emotional states (Fisher & Birch, 2002). This problematic eating behavior is associated with weight gain (Williamson et al., 1995) and binge eating (Howard & Porzelius, 1999). Eating in the absence of hunger in obese individuals may be caused by an unchanged preference for high-energy foods. Thus, it is expected that even though obese individuals are satiated, they still find high-energy foods just as tasty as when they are in a state of hunger.

People have a natural preference for high-energy foods (Nijs, Muris, Euser, & Franken, 2010). This preference for high-energy food may lead to a higher consumption of energy dense foods and increases the risk of becoming overweight or obese (Mela, 2001). The energy content of food and the hunger state of the individual have an influence on eating behavior. When people are in a hungry state they have a greater preference for foods with high energy content and the food is rated as more pleasant, whereas the preference in a satiated state goes to low-energy foods (Charbonnier, van der Laan, Viergever, & Smeets, 2015; Murray & Izquierdo, 2007; Siep et al., 2009; van der Laan, de Ridder, Viergever, & Smeets, 2011). Research on these brain mechanisms have gained insight in the neural processes of eating behavior (Kringelbach, O'Doherty, Rolls, & Andrews, 2003; Rolls & Grabenhorst, 2008; van der Laan et al., 2011). For example, neural activation in areas involved in metabolism, reward and memory is higher in the hungry state while viewing food images and during viewing of high-energy foods compared to low-energy foods (van der Laan et al., 2011).

However, the effect of hunger state might be different in overweight people. Brain responses to food images in areas associated with cognitive evaluation and motivation are different between normal weight and overweight individuals (Brooks, Cedernaes, & Schiöth, 2013; Mela, 2006; Stoeckel et al., 2008). People who had trouble maintaining a normal weight found high calorie foods more rewarding, found foods less satiating, and showed problems when trying to inhibit their eating (Blundell et al., 2005). Furthermore, there was a diminished reward response in obese individuals compared to people with normal weight in response to rewarding tastes (Stice, Spoor, Bohon, Veldhuizen, & Small, 2008). This suggests that obese people may be overvaluing the reward associated with food in a state of satiety to compensate for insufficient reward, leading to overeating (Kennedy & Dimitropoulos, 2014). Nonetheless, overweight people do not have higher preference ratings for either high-energy or low-energy foods than healthy weight people (Dressler & Smith, 2013).

People with obesity are more sensitive to external eating cues than normal weight people and do not respond appropriately to internal cues (Remick, Polivy, & Pliner, 2009). For example, in obese people the amygdala is more active in response to visual and taste cues as opposed to internal cues (Costafreda, Brammer, David, & Fu, 2008). This supports the idea that obese people rely more on external food cues than internal food signals (Kennedy & Dimitropoulos, 2014). These differences in how people process external and internal eating cues may contribute to overeating, which can lead to obesity (Kennedy & Dimitropoulos, 2014). Activation in crucial brain regions involved in arousal, reward processing, memory, anticipation and interoception are different in obese individuals (Kennedy & Dimitropoulos, 2014). A decrease in interoceptive processing in a hungry state may indicate that obese people are not eating in response to internal hunger cues, whereas a decrease in interoceptive processing in a fed state may indicate that obese people are overeating as a result of a poor satiety response and reduced feeling of fullness (Kennedy & Dimitropoulos, 2014). This could be an argument for the little to no difference in preference between a hungry and sated state in obese people. They feel less full and therefore the rated pleasantness between a hungry and sated state may show a smaller difference in obese individuals than in healthy weight people.

Overweight people have a bias in the attention to food images during both a hungry and sated state, whereas in normal weight people the food-related bias in attention is reduced in a sated state in comparison to a hungry state (Nijs et al., 2010). Moreover, it was reported that there was an enhanced food-related gaze direction and duration bias in obese individuals as compared to normal-weight participants in a state of satiety (Castellanos et al., 2009). This suggests that normal weight people in a sated state find food less pleasant than in a hungry state and this difference is not found in obese individuals.

Preference of food is the biggest motivator for eating. Studies done on preference of food are mostly aimed at the effect of weight (Blundell & Finlayson, 2004; Cox, Hendrie, & Carty, 2016; Dressler & Smith, 2013; Lowe & Butryn, 2007) or hunger (Hetherington, Pirie, & Nabb, 2002; Yeomans & Symes, 1999). The inconsistent results reported by these studies may indicate that weight as well as hunger status play a role in rating preference. There might be an interaction of hunger status and weight on rating preference. Because there is little research on the differences in rating the preference of foods in overweight and healthy weight people in either a hungry or satiated state, the objective of this study was to investigate the effect of hunger/satiation and weight on the preference of food. It is hypothesized that there will be an interaction effect. The higher the weight, the more pleasant the food will be rated when satiation is high as well. In addition, it was also investigated if the main effects of hunger and weight and the interaction are different for high-energy and low-energy foods. It is hypothesized that there will be a higher preference rating for high-energy than low-energy food, especially in the hungry state.

To investigate the research questions more thoroughly, a sub experiment was conducted in which two conditions were created; hungry and satiated.

Method

Participants

Participants were recruited online through various social media websites and by distributing flyers and posters at the university campus. After excluding the participants who did not complete the test, 136 individuals remained and were examined in this study. Table 1 shows the demographic characteristics of the population.

Table 1

Mean (M) and standard deviation (SD) of age, BMI, hunger and desire to eat in men, women and the total population.

	Age	Body Mass Index	How hungry are you at this moment?	How much would you like to eat at this moment?
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Male (*N* = 33)	36.12 (17.11)	23.81 (3.50)	3.67 (2.13)	4.24 (2.11)
Female (*N* = 103)	27.86 (13.61)	21.64 (2.63)	4.32 (2.47)	4.93 (2.61)
Total (*N* = 136)	29.87 (14.90)	22.17 (3.00)	4.16 (2.38)	4.76 (2.51)

Experimental design

Nonfood images were used as a control condition. The dependent variable is the mean score on preference rating. Independent variables are Hunger Status and Body Mass Index.

Procedure

Participants were informed and assured that their data would be treated confidentially. After reading the instructions participants started the task. Participants were asked to fill in demographic data, such as age, gender, weight, height and level of education. Following this, they filled out several questions concerning hunger ('How hungry are you at this moment?', 'How much would you like to eat right now?', 'When did you have your last meal?'), allergies ('Do you have any food allergies?') , diet (vegetarian, vegan, medical prescribed diet, weight-losing diet) and reason for meal termination ('everyone else is finished', 'I've had all I'm allowed', 'the food stops tasting good', 'the food is all gone', 'I feel full' or 'other reason'). Next, participants received instructions for the task. Participants were shown an image (food or non-food in random order) and had to answer several questions such as 'At this moment, how tasty do you think this product is?' (1, not tasty – 9, tasty), 'How healthy do you think this product is?'(1, not healthy – 9, healthy) and 'How many calories does this product contain?' (1, very few calories – 9, many calories). These questions were followed by items from the Self-Assessment Manikin (SAM) scale to ask participants about the valence (1, unhappy – 9, happy) and state of arousal (1, calm – 9, excited) of the images. When showing a non-food image, only the SAM scales were used. All questions were answered on a 9-point Likert scale. Every participant was shown a total of 50 images.

Materials

The experiment was built using the program LimeSurvey[1]. The Full4Health Image Collection was used as a stimulus set (Charbonnier, van Meer, van der Laan, Viergever, & Smeets, 2015). There was a total of 200 images (160 food, 40 non-food). 80 images had a low energy content and 80 images had a high energy content. In total, there were four versions of the rating task, each consisting of 40 food images, divided equally over high energy and low energy food images and equal numbers of savory and sweet food images, and 10 non-food images, which were pictures of common office supplies.

[1] LimeSurvey Project Team. Carsten Schmitz (2015). LimeSurvey: An Open Source survey tool. LimeSurvey Project Hamburg, Germany. URL http://www.limesurvey.org

Statistical analyses

To answer the research question the following statistical analyses were executed. A multiple regression to test for the effects of hunger status and weight on the preference of food. The independent variable hunger status was measured with the questions “How hungry are you at this moment?” and “How much would you like to eat right now?”. Because these questions correlated highly, $r(134) = .836$, $p < .001$, only the mean score on the question “How much would you like to eat right now?” was used in de analyses. Body Mass Index was used as the independent variable for weight and for the dependent variable preference of food, the mean score on the question “At this moment, how tasty do you think this product is?” was used.

For the effects of hunger status and weight on high- and low-energy food preference, a multiple regression was executed, with hunger status and BMI as independent variables and the mean liking rating on high- or low-energy foods as dependent variable.

Secondary experiment: Within subject manipulation of satiation

27 of the total participants were asked to do the rating task twice, once right before eating a meal and once directly after eating a meal. This was to create the two conditions; hungry versus satiated. The test made before eating a meal was one of the four versions used to test the whole population and for the test taken after eating a meal a separate version of the test was made consisting only of the questions concerning hunger (‘How hungry are you at this moment?’, ‘How much would you like to eat right now?’, ‘When did you have your last meal?’) and the rating task. Table 2 shows the demographic characteristics and the manipulation of the two conditions.

Table 2

Mean (M) and standard deviation (SD) of age, BMI and hunger status in the two conditions.

	Age	Body Mass Index	Before Meal	After Meal
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Male ($N = 4$)	34.25 (15.26)	24.48 (2.25)	5.50 (1.29)	3.25 (2.63)
Female ($N = 23$)	23.43 (6.32)	22.37 (2.41)	6.57 (1.31)*	2.04 (1.26)*
Total ($N = 27$)	25.04 (8.72)	22.68 (2.46)	6.37 (1.42)*	2.22 (1.42)*

*Difference between hunger and satiety was significant $p < .001$

For the group of participants who did the task twice, a one-way repeated measures ANOVA was executed with the mean score on the question “At this moment, how tasty do you think this product is?” as the dependent variable, preference of food. The independent variables were the mean score on the question “How much would you like to eat right now?” for hunger state and Body Mass Index for weight.

For the differences between non-food and food, a repeated measures ANOVA was executed with hunger status and BMI as independent variables and the mean liking rating as dependent variable for preference of food. The same was done for high-energy and low-energy images.

All analyses were executed with the program IBM SPSS Statistics 23.

Results

In the multiple regression analysis examining the effect of hunger status, weight and the interaction of hunger status and weight on preference of food, the following results were found. There was a significant effect of hunger on preference, $F(1, 134) = 8.28$, $p = .005$, $R^2 = .06$. Furthermore, an interaction effect of hunger status and weight on preference was found, $F(1, 134) = 7.77$, $p = .006$, $R^2 = .06$. There was no effect of weight alone on preference. To illustrate the interaction effect, BMI was split into two groups according to the median split (21.31). In Figure 1, the interaction effect is presented.

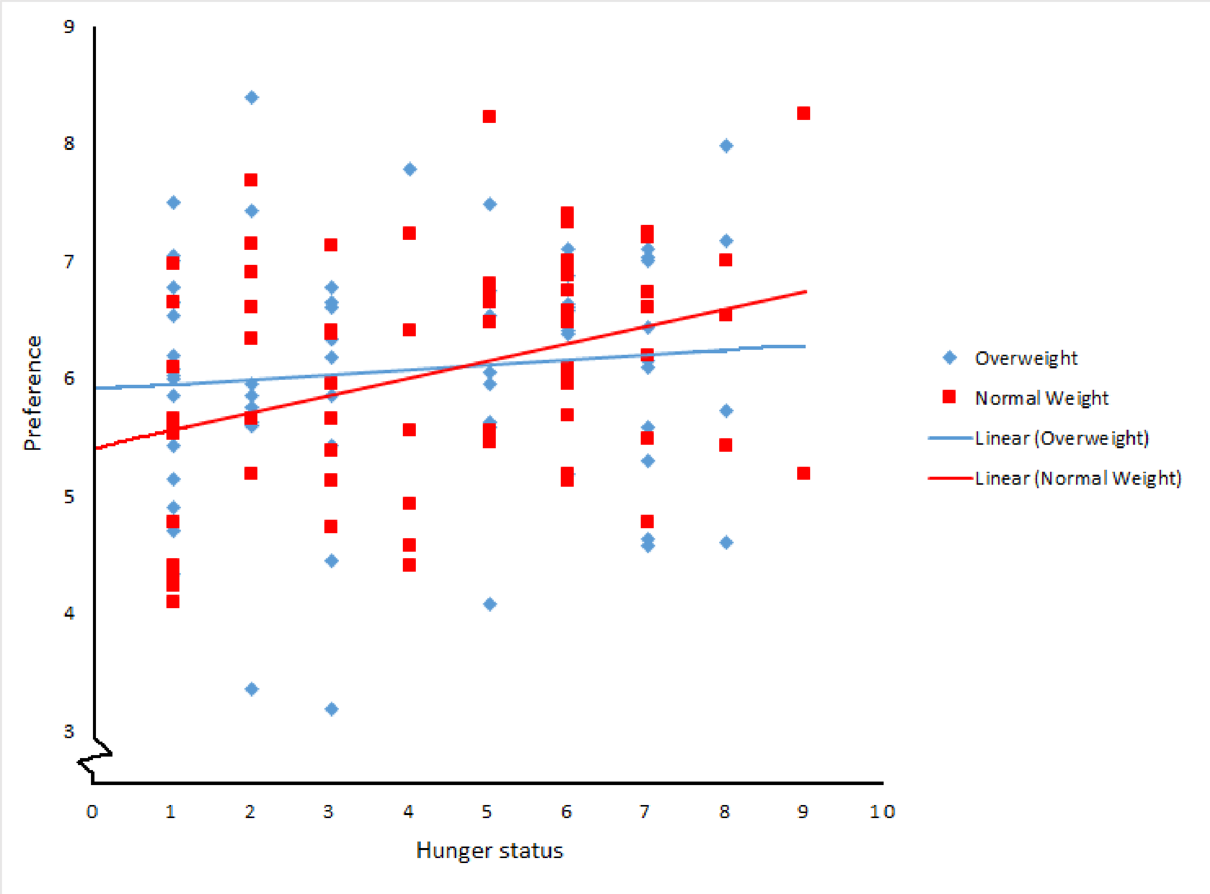

Figure 1. The interaction effect of hunger status and weight on the preference rating of food images.

To test if the main effects of hunger status and weight and the interaction effect on preference of food are different for high-energy and low-energy foods, the multiple regression for the effect of weight and hunger status on high-energy food images showed an effect of hunger on preference of high-energy food images, $R^2 = .08$, $F(1, 134) = 11.82$, $p = .001$ and an interaction effect of hunger status and weight on preference of high-energy food images, $R^2 = .09$, $F(1, 134) = 13.95$, $p < .001$. Again, there was no effect of weight alone on preference of high-energy food images. There were no effects found for weight and hunger status on low-energy food images.

Secondly, a repeated measures ANOVA was executed with the valence and arousal ratings on food and non-food images as dependent variables to control for a difference in preference rating. There was a significant difference between the food and non-food images on valence ratings, $F(1, 135) = 175.70$, $p < .001$, partial $\eta^2 = .57$. The food images were rated higher on valence ($M = 5.90$, $SD = .73$) than the non-food images ($M = 3.98$, $SD = 1.45$). Moreover, there was also a significant difference between the food and non-food images on arousal ratings, $F(1, 135) = 176.51$, $p < .001$, partial $\eta^2 = .57$. The food images were rated higher on arousal (*M* = 4.32, *SD* = 1.44) than the non-food images (*M* = 2.52, *SD* = 1.61). A correlation analysis examining the effect of hunger on the preference rating of food and non-food images (Food images minus Non-food images) showed an effect of hunger status on the difference arousal rating of food and non-food images, $r(134) = .309$, $p < .001$. There was also an effect of weight on the rated valence of food and non-food images, $r(134) = .236$, $p = .006$.

Thirdly, a repeated measures ANOVA of preference ratings on high-energy and low-energy food images was executed, to test for a difference in preference between high- and low-energy foods. This test showed a significant difference between high-energy and low-energy food images $F(1, 135) = 19.11$, $p < .001$, partial $\eta^2 = .12$. Low-energy food images were rated higher on preference (*M* = 6.34, *SD* = 1.06) than high-energy food images (*M* = 5.80, *SD* = 1.41). A correlation analysis exploring the effect of weight and hunger status on the difference of energy content (High-energy minus Low-energy) preference ratings showed an interaction effect of weight and energy content on preference, $r(134) = .212$, $p = .013$ (Figure 2), and an interaction effect of hunger status and energy content on preference, $r(134) = .223$, $p = .009$.

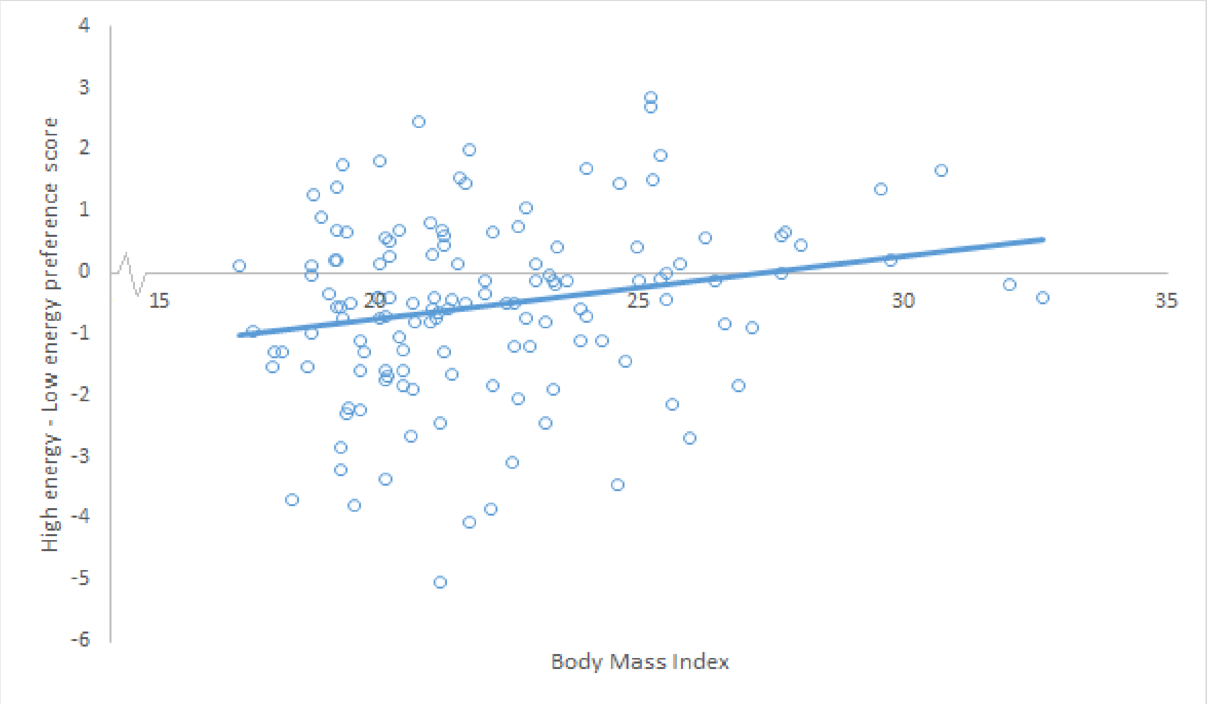

Figure 2. The effect of weight on the difference score of high-energy and low-energy preference ratings.

<u>Secondary experiment:</u>

The repeated measures ANOVA investigating the difference in preference of food between a hungry and satiated state, indicated that the preference did change significantly in a different hunger state, $F(1, 26) = 9.71$, $p = .004$, partial $\eta^2 = .27$. Subjects rated the food images as more pleasant in a state of hunger ($M = 6.36$, $SD = .94$) than in a sated state ($M = 5.60$, $SD = 1.48$). Figure 3 illustrates this difference. There was no effect of weight on the preference rating of food images.

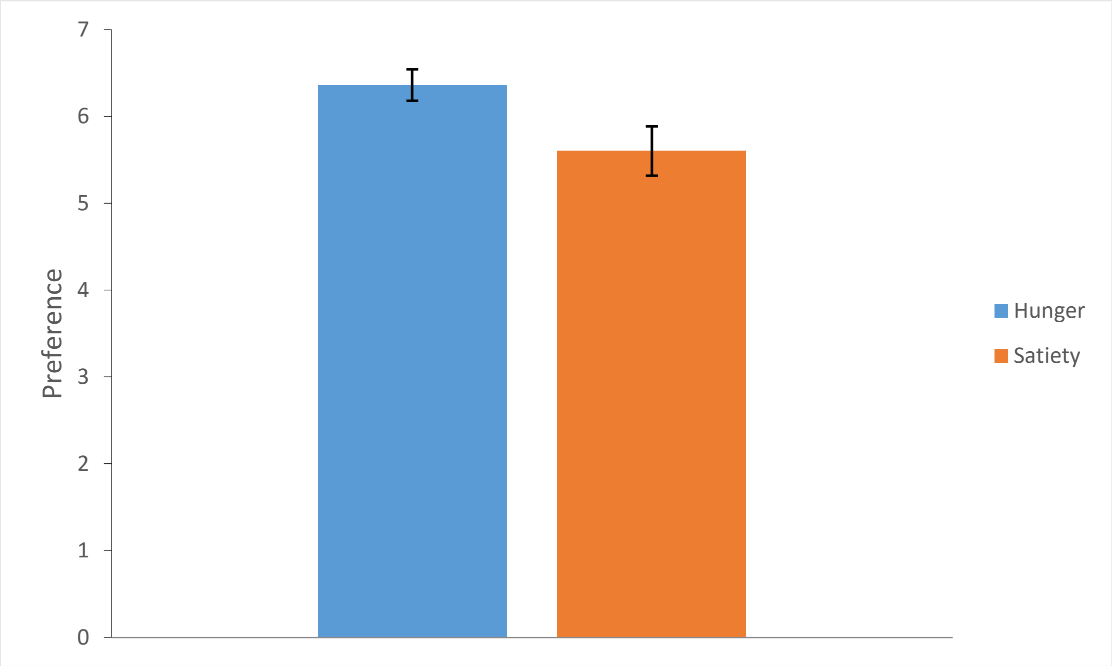

Figure 3. The difference between a state of hunger and a state of satiety on the preference rating of food images.

The repeated measures ANOVA examining the difference in preference rating of high- and low-energy foods showed that there was no significant difference in the preference of high-energy food images between a hungry and sated state. However, there was a significant difference in the preference of low-energy food images between a hungry and sated state, $F(1, 26) = 16.18$, $p < .001$, partial $\eta^2 = .38$. Low-energy food images were rated higher on preference in a state of hunger ($M = 6.50$, $SD = .86$) than in a state of satiety ($M = 5.71$, $SD = 1.30$). There was no effect of weight on the preference rating of high-energy and low-energy food images.

Another repeated measures ANOVA testing the difference in arousal and valence ratings of food and non-food images showed a significant difference in the arousal rating of non-food images between a hungry and sated state, $F(1, 26) = 7.18$, $p = .013$, partial $\eta^2 = .22$. In a state of hunger, the non-food images were rated higher on arousal ($M = 2.60$, $SD = 1.65$) than in a sated state ($M = 1.97$, $SD = 1.23$). There was no significant difference in the valence rating of non-food images between a hungry and sated state. The same difference was found with arousal rating of food images, $F(1, 26) = 16.72$, $p < .001$, partial $\eta^2 = .39$. Food images were rated higher on arousal in a hungry state (*M* = 5.03, *SD* = 1.49) than in a state of satiety (*M* = 3.87, *SD* = 1.33). Moreover, there was a significant difference in the valence rating of food images as well, $F(1, 26) = 10.02$, $p = .004$, partial $\eta^2 = .28$. In a hungry state, food images were rated higher on valence (*M* = 6.05, *SD* = .73) than in a sated state (*M* = 5.55, *SD* = .85). There was no effect of weight on the valence or arousal ratings of food and non-food images.

Discussion

In this study we investigated whether there was an effect of hunger status and weight on the preference ratings of food. The hypothesized interaction effect was confirmed. The difference in preference ratings between hunger and satiety was higher in the people with a lower BMI and there was only a small difference in preference between hunger and satiety in the people with a higher BMI. This same interaction effect was found on preference of high-energy foods, indicating that heavier weight people rate high-energy foods high on preference even when they are satiated. Furthermore, there was an interaction effect of weight and energy content on preference and an interaction effect of hunger status and energy content on preference. Hunger status alone also had an effect on preference of high-energy foods and food images, showing that the greater the hunger, the higher the preference of high-energy foods and food images in comparison to low-energy and non-food images. However, in the sub experiment there was no effect of hunger found on high-energy food images, but on low-energy foods. Moreover, low-energy foods were rated higher when people were hungry than when they were not. The effect of weight on the valence rating of food and non-food images indicates that heavier weight people show a greater difference in the valence between food and non-foods. The sub experiment also showed that food preference did change depending on hunger status.

Our results showed that people with a lower BMI rated food significantly less pleasant when they were satiated and hunger status did not have such an effect on preference rating in people with a higher BMI. They still rated food as pleasant even though they were satiated. An explanation for this dip in preference in healthy weight people could be due to a physiologically effect to maintain a healthy weight, whereas in overweight people this dip in preference is lower, possibly because of a diminished reward response (Stice et al., 2008) or a decrease of interoceptive processing in a sated state (Kennedy & Dimitropoulos, 2014). Overweight people have a high preference for high-energy foods, even when satiated, just as was found in the study by Blundell et al. (2005). On the other hand, in our study there was a clear preference for low-energy food images in people with a lower BMI. This could be, because lighter weight individuals try to maintain a healthy weight and therefore prefer the low-energy foods (Wardle et al., 2004). In this study, the difference in preference for low- or high-energy foods was close to nothing in a state of hunger. From an evolutionary standpoint, we need food to survive, so preference for high- or low-energy foods may not be as important as the innate need to eat. When people are hungry, their attention to food increases (Mogg, Bradley, Hyare, & Lee, 1998; Nijs et al., 2010), because this helps food-deprived individuals detect and get food (Mogg et al., 1998). Therefore food images triggered more feelings of arousal as opposed to non-food images, especially in a hungry state. Moreover, food images elicited more positive feelings in people with a higher BMI than they did in people with a lower BMI. This is in line with the fact that overweight people have a food-related bias in attention (Nijs et al., 2010), evoking more positive feelings towards food images than healthy weight people. Even though the effect of hunger on high-energy foods was found in the total population, this was not the case in the sub experiment. In the sub experiment, there was an effect found of hunger on low-energy food images. This might be due to the differences in demographic characteristics between the two groups. The sub group consisted mostly of young women with a healthy weight, whereas the total population had a better distribution of sex, age and BMI in comparison to the sub group. Healthy young women are more likely to find healthy eating important and have a preference for low-caloric foods (Wardle et al., 2004; Tuschl, Platte, Laessle, Stichler, & Pirke, 1990). This could be an explanation for the higher preference of low-energy foods in people with a lower BMI. Another possible explanation could be that participants gave socially desirable ratings to portray an image of healthy eating preference.

As aforementioned, overweight people have a decrease in interoceptive processing and rely more on external eating cues (Kennedy & Dimitropoulos, 2014). Because of the lack of response to internal cues of hunger, overweight people are more prone to overeating, which is a contributing factor to obesity. With the results of this study, a new development could be made to reduce or even prevent obesity. If overweight people could be learned to rely more on their internal cues and less on the external cues for eating, they might be less likely to overeat and thus become obese. Furthermore, overweight people are more sensitive and responsive to food stimuli in a state of hunger (Nijs et al., 2010) and this could be why overweight people find it difficult to follow a low-energy diet (Turk et al., 2009). These diets lead to constant feelings of hunger, which makes it even more difficult for overweight people to resist temptations of food. People should be more aware of the effect hunger status has on the attention and preference of food and the effect preference has on overeating.

In this study, the effects of hunger and weight were small, probably due to a small dispersion of weight and hunger status. The sub experiment was done to create more control on hunger status and get a clear representation of the differences between hunger and satiety. Even though there was a lack of power in the sub experiment and an uneven divide of weight and hunger status in the total population, the results were present, which could indicate that these are robust effects. To investigate the interaction effect of hunger status and weight on the preference of food more thoroughly, further research is necessary. Future studies should include separate groups based on weight - overweight and healthy weight – to create a clear and more accurate divide between the two groups.

To conclude, there is an interaction effect of hunger status and weight on the preference of food, indicating that individuals with a lower BMI have a decline in preference in a state of satiety, whereas people with a higher BMI do not have this difference in preference. In combination with previous studies, results of this study suggest that both hunger status and weight play an important role in food preference. This could be used to develop a new strategy for reducing and preventing obesity, by increasing awareness of interoceptive hunger cues and decreasing the relying on external cues for eating.

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