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Does immersion or detachment facilitate healthy eating? Comparing the effects of sensory imagery and mindful decentering on attitudes and behavior towards healthy and unhealthy food

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ABSTRACT

Many people would like to reduce indulging in unhealthy foods, but find it difficult to do so. Previous research shows that individuals eat smaller portions of unhealthy hedonic food if they first imagine the sensory properties of tempting food (sensory imagery; Cornil & Chandon, 2016). Similarly, they show less preference for such food if they think about food in a detached way (decentering; Papies, Barsalou, & Custers, 2012; Papies, Pronk, Keesman, & Barsalou, 2015). Given that these two mindsets are seemingly at odds with each other, we compared them across two studies to examine their effects on the preference for (Experiment 1) and consumption of (Experiment 2) hedonic healthy and unhealthy food. Although sensory imagery and decentering had largely different effects for preferences towards healthy and unhealthy foods, they had comparable effects on the consumption of both types of foods, serving to reduce the effects of consumption in participants affected by hunger and emotional eating. These results suggest that while sensory imagery and decentering are based on different mechanisms, they produce similar results when it comes to the consumption of hedonic food, regardless of how healthy the food is.

Healthy eating is important for physical (e.g., Hu, 2002) and psychological health (e.g., Akbaraly, et al., 2009; Jacka, Mykletun, Berk, Bjelland, & Tell, 2011). Some interventions have tried to promote healthy eating by changing the way people think about food (for reviews see Missbach, Florack, & König, 2015; and Tapper, 2017). One such method is based on mindfulness (Papies, Barsalou, & Custers, 2012; Papies, Pronk, Keesman, & Barsalou, 2015). Mindfulness involves focusing attention on experiences occurring in the present moment. Two meta-cognitive processes are thought to underlie the practice of mindfulness (Bishop et al., 2004). The more widely known component involves regulating attention to focus and maintain awareness on a stimulus. When applied to food, this may involve focusing on the experience of eating, such as the sensory properties of the food. The other component involves understanding that all experiences are subjective and transient, rather than reflecting an objective reality or permanent state. This second element has been referred to as "decentering" (e.g., Fresco et al., 2007), "disidentification" (e.g., Lacaille et al., 2014) and "cognitive defusion" (e.g., Schumacher, Kemps, & Tiggemann, 2017).

Regarding the meta-cognitive component of mindfulness that is related to focusing attention, some studies have examined how focusing on the sensory properties of certain food may affect the consumption of another food immediately afterwards (Arch et al., 2016, Experiment 3; Cornil & Chandon, 2016). In a training phase, Arch and colleagues gave participants who had fasted for 2 h prior to the study five raisins to eat and a word puzzle to complete, and asked them to perform both activities simultaneously. Those in the sensory condition were asked to focus on sensations such as the texture, odor, and flavor of the food. In a distraction condition, participants were asked to focus on the puzzle while they ate the food. Those in the control condition were given no specific instructions about how they should perform the activities. In a subsequent free-eating phase, participants were presented with healthy (e.g. carrots, almonds) and unhealthy snacks (e.g. M&Ms, potato chips), and they were told to eat as much of the foods as they wanted so that "they weren't starving", because they had previously fasted. Then participants continued eating the foods in a subsequent food rating task, while they were given the instructions to eat the foods while focusing on the sensations of doing so, as with the raisins previously. There was no difference in food consumption between the sensory and other conditions in the free-eating phase. However, in the food rating task participants in the sensory condition ate fewer calories from unhealthy

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food (and equal calories from healthy food) compared to the control and distraction conditions, even while they rated the food they ate to be more enjoyable than in the other two conditions. This led Arch et al. to suggest that focusing on the sensory properties of food increases the enjoyment of the eating experience, thereby leading individuals to feel that they need to eat less in order to feel satisfied.

Cornil and Chandon (2016) showed that such effects hold even when participants are not explicitly instructed to eat the foods. In a series of studies, participants in the sensory condition were presented with three images of tempting, unhealthy desserts and asked to imagine eating them, with a particular focus on the sensory properties of the food. Those in the control condition were presented with three images of comfortable armchairs and they were asked to imagine how it would feel to sit in each chair. They found that when participants were hungry and not dieting, those in the sensory condition were more likely to choose a smaller portion of (hypothetical or real) chocolate cake to consume compared to those in the control condition. However, unlike Arch et al. (2016), there was no difference in actual eating enjoyment between the sensory and control conditions. It should be noted that, contrary to Arch et al., Cornil and Chandon did not explicitly instruct participants to focus on the sensory properties of food during the test phase, and their evaluations of enjoyment of the food related to anticipated rather than to actual enjoyment of the portion that they subsequently chose, and sometimes consumed. Nonetheless, it appears that thinking about the (real or imagined) sensory properties of food, can reduce unhealthy food consumption, although the mechanism underlying this effect is unclear.

Whereas focusing on the sensory properties of food seems to decrease subsequent consumption of unhealthy food, the second metacognitive component of mindfulness, which will hereafter be referred to as “decentering”, has been shown to increase healthy eating in addition to decreasing unhealthy eating. In the studies of Papies and colleagues (Papies et al., 2012, 2015), participants were presented with images of healthy and unhealthy foods and were asked to either look at the images (passive viewing control condition), or to look at the images and think about their reactions to foods as constructions of the mind, which appear and disappear (mindfulness condition). In Papies et al. (2012), participants were then presented with images of attractive (e.g., fries, pizza), and neutral (e.g., cucumber, raisins) foods,[1] to which they either made an approach or avoid response (button pressing). Although participants in the control condition were faster to make an approach response to unhealthy foods, this effect disappeared in the mindfulness condition. Similarly, in Papies et al. (2015), hungry participants were more likely to choose attractive unhealthy foods in a computer task in the control condition than in the mindfulness condition, and they were more likely to choose neutral healthy foods in the mindfulness than in the control condition. Such results also generalised to real-life food choices in a campus cafeteria, with participants in the mindfulness condition choosing to eat more salads and fewer unhealthy snacks than those in the control condition. Thus, it appears that when individuals think about their reactions to food as being subjective and transient states of mind, they are less attracted to unhealthy food, and more attracted to healthy food, particularly when they are hungry.

These effects of decentering generalise to other studies that have examined chocolate consumption in a sample of chocolate lovers (Forman et al., 2007; Hooper, Sandoz, Ashton, Clarke, & McHugh, 2012; Jenkins & Trapper, 2014; Moffitt, Brinkworth, Noakes, & Mohr, 2012). These studies either manipulated whether participants were asked to decentre from chocolate-related thoughts (Jenkins & Trapper, 2014; Moffitt et al., 2012), or chocolate-related cravings (e.g., “right now, I'm having the thought that I'm craving chocolate, but I can have that craving, and still not act on it”, Forman et al., 2007; Hooper et al., 2012). Interestingly, the studies that applied decentering to *thoughts* showed reduced chocolate consumption whereas those that applied decentering to *cravings* did not reduce consumption, or showed mixed results. For instance, the effect of decentering on chocolate consumption in the study of Foreman and colleagues was moderated by the extent to which people are vulnerable to environmental food cues (as measured by the Power of Food Scale; Lowe et al., 2009). That is, those who were most sensitive to the presence of food showed reduced consumption of chocolate, but not those who were less affected by food cues. There are two possible reasons why asking participants to decentre from chocolate-related thoughts in general may be more effective at reducing chocolate intake than asking them to decenter from chocolate cravings specifically. Firstly, because chocolate-related thoughts also include chocolate cravings, it may be that participants were able to apply this technique to a wider range of thoughts, thus strengthening the manipulation. Secondly, enlarging participants' attention to a wider range of chocolate-related thoughts may have drawn their attention to the varied nature of their reactions towards chocolate to a greater extent than focusing their attention on chocolate cravings, which may have helped them realise that chocolate can represent more than just an object of craving, thus reducing the salience of chocolate temptation.

The mechanism proposed to underlie the effect of decentering on food choice is based on the idea that exposure to tempting food images triggers simulations of consuming the food (Keesman, Aarts, Häfner, & Papies., 2017; Papies et al., 2012, 2015). For example, exposure to a rewarding food (versus a neutral or non-food stimulus) elicits simulations of food consumption, such as spontaneous thoughts of the taste, enjoyment, and eating context of the food (Keesman, Aarts, Vermeent, Häfner, & Papies, 2016; Papies, 2013).

Relatedly, a review of fMRI experiments showed that exposure to food representations (images/words) triggers brain activity in regions that are related to eating, such as those related to taste and reward (Chen, Papies, & Barsalou, 2016). This activity is stronger when the food is particularly rewarding, as when it is hedonic, or when one is hungry. It is thought that because mindfulness involves adopting the perspective that experiences are subjective and temporary, this allows individuals to become less immersed in their reactions toward rewarding stimuli, allowing them to take distance from simulations that may otherwise compel them to approach rewarding food.

The evidence supporting the idea that decentering reduces emotional reactions towards food is somewhat mixed. Although some studies show that decentering reduces food craving (Lacaille et al., 2014; Papies et al., 2015), others do not (Hooper et al., 2012), or they find moderating effects (i.e., Forman et al., 2007 found an interaction with the extent to which people are sensitive to their food environment). Furthermore, reductions in food cravings are not always associated with reduced consumption (Moffitt et al., 2012). More specifically, although Foreman et al. showed that reduced chocolate cravings were related to reduced chocolate consumption, Moffitt et al. found no difference in chocolate craving between conditions even as participants in the decentering group consumed fewer chocolates than those who were asked to challenge their chocolate related thoughts, or those in the control condition.

It is interesting to note that two processes that have been shown to reduce unhealthy food consumption – focusing on the sensory properties of food and decentering – appear to have opposing phenomenological characteristics. Focusing on the sensory properties of food prior to an eating experience relies on being immersed in an eating simulation, whereas decentering is thought to discourage eating simulations. Although opposing mechanisms have been proposed for these different mindsets, with a focus on the sensory properties of food increasing the enjoyment of attractive food, and decentering leading to the devaluation of such food, the evidence for these arguments is mixed. Given that these two processes can both reduce unhealthy eating in very different

[1] According to evaluative ratings from the International affective picture system (IAPS; Lang, Bradley, & Cuthbert, 2008), from where the images where taken.

ways, it would be useful to compare their outcomes in the same study against the same control condition, particularly as the control condition of Cornil and Chandon's (2016) sensory imagery studies did not feature food stimuli, whereas those of the decentering studies did.

Furthermore, in the interest of exploring multiple strategies of healthy eating, the effects of the sensory and decentering mindsets on attractive, healthy food should also be examined. Because eating experiences often consist of a mix of healthy and unhealthy foods that vary in attractiveness, it may be that applying one particular mindset to such an eating experience reduces not only the consumption of unhealthy hedonic food, but also, healthy hedonic food, thereby potentially eliminating a positive component of eating.

1. The present research

In the following studies, we examined the effects of sensory imagery and decentering on participants' preferences for eating healthy and unhealthy hedonic food (Experiment 1), and on their actual consumption of healthy and unhealthy hedonic food (Experiment 2). Our sensory imagery manipulation was based on that of Cornil and Chandon (2016), and our decentering manipulation was based on that of Papies and colleagues (Papies et al., 2012, 2015). These particular manipulations were chosen because they are the most comparable, in the sense that they both involve using food images to train participants in their respective mindset techniques, whereas no other sensory imagery or decentering studies that we know of used comparable training stimuli.

Based on previous research in the literature (Cornil & Chandon, 2016; Papies, 2013, 2015), we predicted that hungry participants in both the sensory and decentering conditions would show less preference for/less consumption of unhealthy food compared to the control condition, but that there would be no difference between conditions for less hungry participants. Although feelings of hunger may lead individuals to choose larger portions, it may be that the mindset manipulations divert individuals' thoughts from their hunger, either by making them think more about the sensory rather than the satiating aspects of food (in the case of imagery), or by distancing them from their subjective (hunger) experience (in the case of decentering).

We also examined whether participant body mass index (BMI) would moderate the effect of the mindset manipulations on food preferences, as Cornil and Chandon (2016) found that sensory imagery sometimes had a stronger effect on low BMI participants, but this individual difference was not examined in the decentering studies of Papies et al. (2012; 2015). Furthermore, the food consumption of people with a higher BMI is less influenced by internal cues such as hunger, compared to those with a lower BMI (e.g., Burton, Smit, & Lightowler, 2007; Tetley, Brunstrom, & Griffiths, 2009). Because the effects of the mindset manipulations have been shown to operate only under conditions of hunger, it may be that people who are less sensitive to such internal states are less affected by such imagery and decentering. Given that Cornil and Chandon found effects of sensory imagery within non-dieters only, we also examined whether dietary restraint (the extent to which people try to restrict their calorie consumption) moderates these effects. In contrast, dieting did not have an effect in the decentering study of Papies et al. (2012), although it did seem to influence responses in the control condition in Papies et al. (2015, Experiment 3), with dieters eating more healthily in the control condition than non-dieters. Based on past research, we expected the effect of sensory imagery would lead participants to prefer smaller portions compared to the control condition in non-dieters only. Besides the aforementioned interactions, we were agnostic as to whether there would be any differences between the sensory imagery and decentering conditions. We were also agnostic as to how the two manipulations would affect attitudes and behaviour towards healthy, hedonic food.

In Experiment 1 participants rated how willing they were to eat a variety of healthy and unhealthy foods that they rated to be equally tempting (fruit-based vs. cream/pastry based-desserts), and they were asked to choose their preferred portion size of a healthy dessert and an unhealthy dessert. In Experiment 2 participants were offered healthy unsalted almonds and unhealthy M&Ms as part of a bogus taste test, and we measured how much of each type of food they ate. We also measured how much participants imagined they would enjoy eating the test foods (Experiment 1), and how tasty they thought each food was (Experiment 2). In both experiments we also assessed the effects of the continuous moderators of hunger, restrained eating (i.e., dietary restraint), and BMI.

2. Experiment 1

2.1. Method

2.1.1. Participants

We conducted a power analysis using G*Power based on the effect size reported in Papies et al. (2015, Experiment 2). Based on this analysis, 191 participants were required to detect an interaction effect of $\Delta R^2 = 0.04$ between hunger and the decentering versus control condition, at 0.80 power at alpha = .05. Thus 191 participants were recruited ($M_{age} = 28.72$, $SD = 11.31$; 47.2% female, 46.7% male, and 0.5% who self-identified as 'other'). Sixty-three of the participants were first-year French-speaking psychology students from a Belgian university who performed the French language version of the study online in a laboratory in exchange for course credits. The remaining participants performed the English language version of the study online outside of the laboratory. Seven of these were English-speaking students from a Hungarian university who performed the study in exchange for course credits, and 121 were English speakers from the online crowdsourcing platform Prolific Academic (https://prolific.ac/) who performed the study for £1.70 for up to 20 min, and who ranged from age 18–59. All studies reported in this paper were approved by the ethical committee of the Université Libre de Bruxelles.

2.1.2. Design

The design consisted of a between-participant factor of condition with 3 levels (sensory imagery, decentering, control) × a within-participant variable of outcome type with 2 levels (food choice vs. quantity) × within-participant variable of food type with 2 levels (healthy vs. unhealthy food). Hunger, restrained eating, and BMI were measured as continuous moderators.[2]

2.1.3. Procedure

The experiment was conducted online via the Qualtrics survey platform (https://www.qualtrics.com/). After participants indicated their consent by clicking a box, they were randomly assigned to either the sensory condition, the decentering condition, or a control condition by a computer program, thus making both the participant and experimenter blind to the manipulation. Participants in all conditions first underwent the training phase in which they were presented with eight images of hedonic, healthy, fruit-based desserts (e.g. tropical fruit salad, poached pear, watermelon granita), and eight images of hedonic, unhealthy desserts (e.g., chocolate éclair, ice-cream, cheesecake). Each image was presented for 12 s, and the order of the images was randomised. This phase took about 4 min, and thus could be considered to induce a type of "mindset" rather than providing extensive training.

In the sensory condition, participants were asked to imagine as vividly as possible the taste, smell and mouth texture of each food as they were presented with each image. After the images were presented, participants rated the degree to which they were able to imagine the

[2] We also measured the potential mediators of the perceived appetisingness of healthy and unhealthy foods, and the perceived enjoyableness of the preferred portion of food chosen. Data relating to all experiments presented in this paper, including these mediators can be found at https://osf.io/8j7t3.

taste, smell, and mouth texture of each food on a scale of 1 = *not at all*, to 7 = *very much so*.

For the decentering condition, participants were first told that they were to view a number of images, to which they will probably experience all kinds of reactions, such as liking or disliking, or wanting to have what is in the image. They were instructed to consider the character of their thoughts and reactions to these images and to try to imagine that thoughts are constructions of the mind, which appear and disappear. Because reactions to external stimuli differ considerably between people and between situations, these reactions are not really part of the images, but rather what the mind happened to make of them at that moment. Thus, participants were asked to observe their thoughts as transient states of mind. They were asked to apply this principle while viewing a number of images and to simply observe their reactions, without suppressing or avoiding them. After the task, participants rated the degree to which they were able to imagine their thoughts in response to the images as transient mental events on a scale of 1 = *not at all*, to 7 = *very much so*.

The control condition was based on that used by Papies et al. (2015, Experiment 2). Participants were instructed to simply look at the food images closely in a relaxed manner. For the experimental condition, a brief reminder of the instructions was presented above each image on the screen. In the sensory condition this was "How would this food taste, smell, and feel in your mouth?", and in the decentering condition this was "What are your reactions to this image at the moment?"

Then participants completed two tasks in a counterbalanced order: 1) a portion preference task, and 2) a food evaluation task. For the portion preference task, participants were presented with images of six portion sizes of chocolate cake (the same stimulus as that used in Cornil & Chandon, 2016), and images of six portion sizes of mixed berries, and they had to choose which portion size of each food they preferred to eat at that moment. After each choice, on the following page they were presented with their chosen portion and they were instructed to estimate how much they expected to enjoy eating it, ranging from 1 ("I would not enjoy eating it at all") to 7 ("I would enjoy eating it a lot"). The chocolate cake task and the mixed berries task were presented in a counterbalanced order.

For the food evaluation task, participants saw images of four types of unhealthy desserts, and four types of healthy desserts. Participants were asked how willing they would be to eat each food *right now*, on a scale of 1 = *not at all willing*, to 7 = *yes, definitely*. Following this, they rated how appetising they considered each of the foods to be (1 = *not at all appetising*, to 7 = *extremely appetising*). The order of presentation was randomised in each case.

Next, participants' level of hunger was measured using the same two items as that used in Papies et al. (2012, 2015) and Cornil and Chandon (2016): a) *How hungry do you feel at the moment?* (1 = not at all, 7 = extremely) and b) *How long ago did you last eat?* (1 = *over 6 h ago*, to 7 = *within the last hour*). However, these two measures were not reliable (α = 0.40), so we only analysed the responses to the first question, which measured hunger more directly. As in their studies, we measured hunger after the independent variable in order to avoid drawing participants' attention to the food-related focus of the study and to reduce demand effects.

Participants also completed the restrained eating scale of the Dutch Behaviour Eating Questionnaire (DEBQ, Van Strien, Frijters, Bergers, & Defares, 1986, α = 0.82), and reported their height and weight, with which we calculated their body mass index (BMI). Two attentional check questions were included to verify that participants paid sufficient attention to the task (e.g., for one question participants were asked how often they listened to classical music, and were asked to select the first response). Lastly, participants underwent a funnel debriefing procedure. Participants were first asked what they though the purpose of the study was, and whether viewing the pictures at the beginning of the study influenced their subsequent responses. No participants guessed the purpose of the study, nor did they indicate that the manner in which they viewed the pictures influenced how they felt about the food – they only mentioned that looking at desserts in the training phase made them feel hungrier.

2.2. Data analysis

Participants' willingness to eat healthy and unhealthy desserts was calculated by taking the mean of their ratings of willingness to eat healthy and unhealthy desserts (unhealthy desserts α = 0.82 - 0.84; healthy desserts α = 79 - 0.83, depending on counterbalancing condition). How appetising they perceived the food to be was calculated following the same principle depending on counterbalancing condition (unhealthy desserts α = 0.82-0.84, healthy desserts α = 0.79- 0.83, depending on counterbalancing condition), as was how enjoyable they thought it would be to eat the desserts (unhealthy desserts α = 0.81 in both counterbalancing conditions, healthy desserts α = 0.77-0.83, depending on counterbalancing condition). Healthy and unhealthy desserts did not demonstrably differ in their how appetitive they were considered to be in the control condition ($t(65) = 1.28$, 95% CI [−0.14, 0.64], $p = .20$, $d = 0.48$). To support these analyses, we used a Bayesian approach to test the null hypothesis that there were no differences in perceived appetitiveness between the two types of food. Our alternate model specified a half-normal distribution of effect sizes centered on zero (i.e., suggesting that small effect sizes are more frequent than larger ones, cf. Dienes, 2011).[3] These analyses revealed a Bayes factor of 0.34, which is conventionally considered as strong support for the null hypothesis (see, for example, Rouder, Speckman, Sun, Morey, & Iverson, 2009). This result attests to the face validity of our manipulation. Data from two participants were excluded because they gave incorrect responses to multiple attention check questions, suggesting that they paid insufficient attention to the task.

2.3. Results

The descriptive statistics of the participants are presented in Table 1.

To examine which factors best predicted each dependent variable (i.e., willingness to eat unhealthy/healthy desserts, and preferred portion size of chocolate cake/berries), we conducted a hierarchical linear regression analysis for each dependent variable, with nested orthogonal condition contrasts (experimental conditions (1, 1) vs. control (−2); sensory imagery (1) vs. decentering condition (−1)) and the moderators of hunger, restrained eating, and BMI, which were previously centered. These variables were entered simultaneously in the first block to control for the effects of the moderators on the condition contrasts, and the interactions between the moderators and condition contrasts (which were simply the product of the two standardised variables) were entered in the second block.

Analyses with sample type (francophone participants performing the experiment in the lab vs. anglophone participants performing the experiment online) as an additional predictor and moderator revealed that this variable did not interact with any of the higher order significant effects, and so the analysis was collapsed across the two samples. Table 2 depicts the standardised regression coefficients of these analyses.

2.3.1. Willingness to eat unhealthy (non-fruit) desserts

Participants were more willing to consume the unhealthy desserts if they were hungry ($t(179) = 6.22$, 95% C.I. = [0.24, 0.46], $p = .000$), and if they had a higher BMI ($t(179) = 2.91$, 95% C.I. = [0.20, 0.10], $p = .004$). There was a significant interaction between restrained eating and the sensory versus decentering condition ($t(173) = -2.00$, 95%

[3] This was conducted using a Bayesian calculator from http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/Bayes.htm.

Table 1
Descriptive statistics of Experiment 1.

	Overall mean (N = 188)	Sensory (N = 59)	Decentering (N = 63)	Control (N = 66)
Hunger	4.06 (1.66)	4.31 (1.74)	3.79 (1.71)	4.11 (1.53)
Restrained Eating	2.60 (0.87)	2.57 (0.99)	2.65 (0.87)	2.57 (.76)
BMI	23.68 (4.44)	24.06 (4.50)	23.27 (4.64)	23.73 (4.21)
Preferred cake portion	3.10 (1.67)	3.18 (1.79)	2.87 (1.56)	3.26 (1.66)
Preferred berries portion	3.37 (1.45)	3.61 (1.46)	3.05 (1.39)	3.47 (1.47)
Enjoyableness of Cake Portion	5.10 (1.78)	4.84 (1.98)	4.97(1.80)	5.45 (1.53)
Enjoyableness of Berries portion	5.30 (1.71)	4.98 (1.86)	5.32(1.71)	5.56 (1.55)
Willingness to eat unhealthy desserts	4.41 (1.44)	4.54 (1.59)	4.17(1.39)	4.52 (1.34)
Willingness to eat healthy desserts	4.54 (1.32)	4.45 (1.33)	4.51(1.27)	4.63 (1.38)
Perceived appetizingness of unhealthy desserts	4.74 (1.25)	4.74 (1.50)	4.63 (1.22)	4.84 (1.04)
Perceived appetizingness of healthy desserts	4.54 (1.21)	4.48 (1.25)	4.54 (1.21)	4.59 (1.18)

Note. SDs are in parentheses.

Table 2
Standardised regression coefficients in Experiment 1 for preferred portion of cake, preferred portion of berries, and willingness to eat (unstandardised coefficients, standard error in parentheses).

		Unhealthy Willingness *B*	Healthy Willingness *B*	Cake Portion *B*	Berries Portion *B*
Step 1	Hunger	0.41 (0.35, 0.06)***	0.17 (0.14, 0.06)*	0.35 (0.35, 0.07)***	0.26 (0.23, 0.06)**
	BMI	0.12 (0.06, 0.02)**	−0.13 (−0.04, 0.02)	0.21 (0.08, 0.03)**	0.03 (0.01, 0.02)
	Restraint	−0.18 (−0.30, 0.11)**	0.07 (0.10, 0.12)	−0.05 (−0.09, 0.14)	0.04 (0.07, 0.13)
	Experimental vs. Control	−0.03 (−0.03, 0.06)	−0.05 (−0.05, 0.07)	−0.05 (−0.06, 0.08)	−0.04 (−0.04, 0.07)
	Sensory vs. Decentering	0.03 (0.04, 0.12)	−0.02 (−0.03, 0.12)	0.00 (0.00, 0.14)	0.11 (0.21, 0.13)
	F	12.68***	1.56	8.12	3.57**
	R^2	0.26	0.04	0.19	0.09
Step 2	Hunger	0.40 (0.34, 0.06)***	0.18 (0.14, 0.06)*	0.33 (0.33, 0.07)***	0.28 (0.25, 0.06)***
	BMI	0.20 (0.06, 0.22)**	−0.16 (−0.05, 0.02)*	0.22 (0.08, 0.03)**	0.01 (0.00, 0.03)
	Restraint	−0.18 (−0.30, 0.12)*	0.11 (0.17, 0.12)	−0.05 (−0.10, 0.14)	0.09 (0.14, 0.13)
	Experimental vs. Control	−0.04 (−0.04, 0.06)	−0.05 (−0.05, 0.07)	−0.06 (−0.07, 0.08)	−0.06 (−0.06, 0.07)
	Sensory vs. Decentering	0.02 (0.34, 0.12)	−0.03 (−0.05, 0.12)	0.00 (0.00, 0.14)	0.12 (0.19, 0.13)
	Hunger x Experimental vs. Control	0.06 (0.04, 0.04)	0.02 (0.14, 0.04)	0.03 (0.04, 0.05)	−0.04 (−0.02, 0.05)
	Hunger x Sensory vs. Decentering	0.04 (0.04, 0.07)	0.01 (0.01, 0.07)	0.00 (0.00, 0.08)	0.19 (0.20, 0.08)**
	BMI x Experimental vs. Control	−0.03 (−0.01, 0.02)	0.13 (0.03, 0.18)	−0.01 (−0.04, 0.02)	0.16 (0.04, 0.02)**
	BMI x Sensory vs. Decentering	−0.08 (−0.03, 0.03)	−0.11 (−0.04, 0.03)	−0.03 (−0.07, 0.03)	−0.10 (−0.04, 0.03)
	Restraint x Experimental vs. Control	0.02 (0.03, 0.09)	−0.08 (−0.09, 0.10)	0.06 (0.04, 0.11)	−0.03 (−0.04, 0.01)
	Restraint x Sensory vs. Decentering	−0.13* (−0.25, 0.13)	−0.05 (−0.08, 0.13)	−0.55 (−0.24, 0.15)***	−0.01 (−0.02, 0.14)
	F	6.49***	1.27	5.36	2.91**
	R^2	0.29	0.07	0.26	0.16

Note. $^+$ $p = .06$, * $p < .05$, ** $p < .01$, *** $p < .001$. Including the interaction term in Step 2 renders associated main effects in the same step uninterpretable.

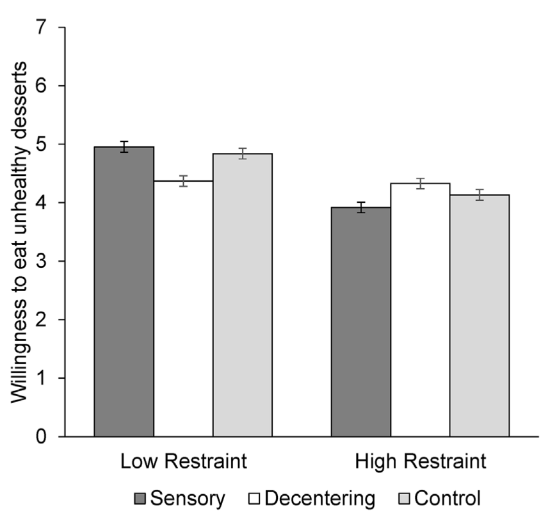

Fig. 1. Mean willingness to eat unhealthy desserts at low (1 SD below the mean) and high (1 SD above the mean) levels of restrained eating for each condition in Experiment 1. The error bars represent the prediction intervals, based on the standard error of the residuals.

C.I. = [−0.50 to −0.00], $p = .048$). Fig. 1 shows participants' mean willingness to eat unhealthy desserts at low (1 SD below the mean) and high (1 SD above the mean) levels of restrained eating for each condition.

Simple slopes analyses showed that amongst low restrained eaters, there was a slight tendency for participants to be more willing to eat unhealthy desserts if they were in the sensory than in the decentering condition, $B = 0.29$, $t(119) = 1.72$, $p = .09$., whereas there was no such difference between the conditions amongst high restrained eaters, $B = -0.21$, $t(119) = -1.20$, $p = .23$.

2.3.2. Willingness to eat healthy (fruit) desserts

The only significant predictor of the willingness to eat healthy desserts was hunger, $t(179) = 6.22$, 95% C.I. [0.24, 0.46], $p = .000$. As with unhealthy desserts, hungrier participants were more willing to eat healthy desserts.

2.3.3. Preferred portion of chocolate cake

There was a significant interaction between restrained eating and the sensory versus decentering condition, $t(179) = -3.62$, 95% C.I. [−0.84, −0.25], $p = .000$. Fig. 2 shows participants' preferred portion of chocolate cake in each condition at low and high levels of restrained eating (1 SD below and above the mean, respectively).

Simple slopes analyses indicated that amongst low restraint eaters, participants chose a larger portion of chocolate cake in the sensory than in the mindfulness condition ($B = 0.55$, $t(119) = -2.69$, $p = .008$).

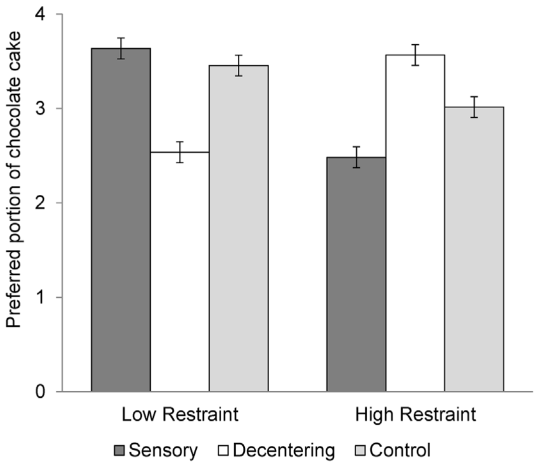

Fig. 2. Preferred portion of chocolate cake in each condition of Experiment 1 at low and high levels of restrained eating (1 SD below and above the mean, respectively). The error bars represent the prediction intervals, based on the standard error of the residuals.

This pattern was reversed amongst high restrained eaters, who chose a larger piece of cake in the mindfulness than the sensory condition ($B = -0.54$, $t(119) = -2.64$, $p = .009$).

2.3.4. Preferred portion of berries

Hungrier participants preferred a larger portion of berries, $t(179) = 3.52$, 95% C.I. [0.10, 0.35], $p = .001$. This effect interacted with the sensory versus decentering condition $t(172) = 2.70$, 95% C.I. [0.05, 0.35], $p = .008$. Participants' preferred portion of berries at low and high levels of hunger for each condition are depicted in Fig. 3.

Simple slopes analyses showed that hungrier participants preferred a larger portion of berries in the sensory than in the decentering condition ($B = 0.41$, $t(119) = 3.12$, $p = .002$), but that there was no difference between the conditions at low levels of hunger ($B = 0.00$, $t(119) = 0.02$, $p = .98$.

There was also a marginal interaction between BMI and the experimental conditions (both the sensory and decentering conditions combined) versus the control, $t(179) = 2.03$, 95% CI [0.01, 0.08], $p = .044$. Amongst participants with a low BMI, a larger portion of berries was preferred in the control than in the experimental conditions combined and this pattern of means was reversed amongst higher BMI

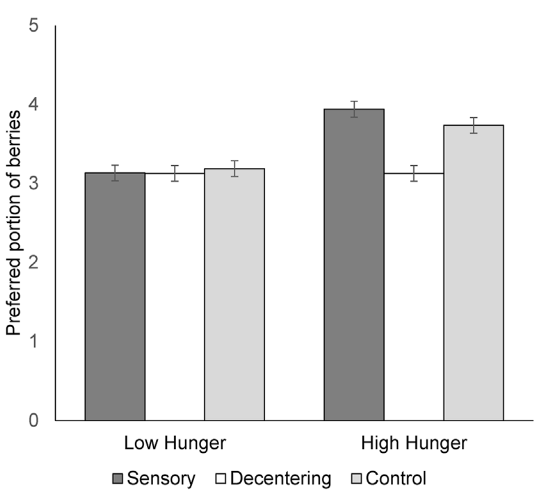

Fig. 3. Preferred portion of berries at low and high levels of hunger (1 SD below and above the mean, respectively) for each condition of Experiment 1. The error bars represent the prediction intervals, based on the standard error of the residuals.

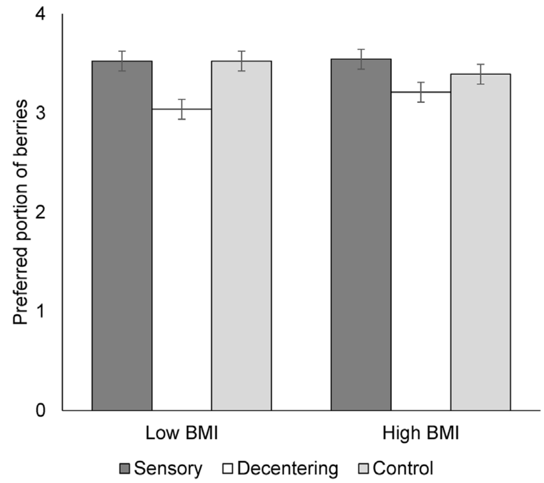

Fig. 4. Preferred portion of berries in each condition of Experiment 1 as a function of low and high BMI (1 SD below and above the mean, respectively). Error bars represent prediction intervals, based on the standard error of the residuals.

participants. However, simple slopes analyses at 1 SD below and above the mean did not reveal any significant difference between the control versus experimental conditions when participant BMI was either low (B = - 0.08, $t(171) = -1.15$, $p = .25$), or high (B = - 0.00, $t(171) = -0.07$, $p = .94$). Fig. 4 depicts participants' preferred portion of berries in each condition as a function of BMI.

Looking at the pattern of means in Table 1, it appears possible that the experimental conditions affected reported hunger, which was measured towards the end of the experiment. That is, it may be the case that sensory imagery increased hunger, whereas the decentering condition decreased it. To examine whether this was the case, we conducted the same regression analyses as above, except with hunger as an outcome instead of as a predictor. Although there was a trend towards participants reporting greater hunger in the sensory imagery condition compared to the decentering condition, this effect was not significant $t(181) = 1.71$, 95% C.I. [−0.04, 0.55], $p = .09$.

2.4. Discussion

Experiment 1 showed that hungrier participants preferred a larger portion of berries in the sensory condition, compared to the decentering condition. This result appears to be consistent with Papies et al.'s (2012; 2015) results with unhealthy, but hedonic food, rather than their results with healthy, but neutral, food. Thus, it appears that the effects of decentering are dependent on the hedonic nature of the food involved, rather than on its healthy nature.

We also found that dietary restraint played a role in willingness to eat unhealthy desserts, with participants being more willing to eat unhealthy desserts if they were in the sensory rather than the sensory condition. A similar effect was found in terms of the size of chocolate cake selected, with low restrained eaters preferring a larger portion in the sensory than the decentering condition, but the opposite pattern occurred amongst high restrained eaters.

Taken together, these results suggest that decentering may induce high restrained eaters to be less restrained. It may also be that the sensory condition makes high restrained eaters even more restrained. In support of these possibilities, previous research demonstrates restrained eaters' dieting goals are primed when they are exposed to tempting food stimuli (Coelho, Polivy, Herman, Pliner, 2009; Fishbach, Friedman, & Kruglanski, 2003; Experiment 4; but see; Coelho, Polivy, Herman, & Pliner, 2008), Therefore, to the extent that unhealthy, tempting food cues may elicit reactions that activate a dieting goal, it may be that encouraging participants to take distance from their reactions in the decentering condition may reduce their aversion to such cues. Furthermore, it may be that the vivid imagery of the sensory manipulation may highlight the tempting aspects of the food stimuli in the sensory condition, thereby triggering goal activation in restrained eaters even more strongly.

If decentering does reduce emotional reactions, then its effects may be moderated by emotional eating, which is the extent to which people eat in order to regulate their emotions. Those who are high in emotional eating have a greater tendency to approach rewarding stimuli (Eisenstein et al., 2015). Thus, reducing the rewarding value of food through decentering may have a greater effect for those who are more sensitive to such rewards. In our next study we examined the extent to which emotional eating may moderate the effect of decentering, using the emotional eating subscale of the Three-Factor Eating Questionnaire (Stunkard & Messick, 1985), which measures the extent to which people eat when they experience negative emotions.

We also sought to determine whether the effects of Experiment 1 could be replicated with the actual consumption of food. This paradigm allowed us to check whether sensory imagery may increase the pleasantness of people's eating experience, as proposed by Arch et al. (2016). We examined this in Experiment 2 by presenting participants with healthy and unhealthy food (almonds and M&Ms, respectively), and asking them to rate how appetizing and pleasant each food was after tasting them.

In Experiment 1, participants rated their hunger after the manipulation (and the food rating tasks), which may lead to hunger being influenced by the manipulation. Therefore, in Experiment 2 we measured hunger before the manipulation in order to have a more uncontaminated measure.

3. Experiment 2

Experiment 2 was the same as Experiment 1 except that participants did not rate how willing they were to eat healthy and unhealthy foods, nor did they indicate their preferred portion of chocolate cake/berries, nor did we asked them to rate how appetising they thought certain foods were, and how much they thought they would enjoy eating the portion of cake/berries they had chosen. Instead, participants were presented with a bogus taste test of unhealthy M&Ms and healthy almonds, and they rated the food on various dimensions of taste and evaluated its pleasantness. Furthermore, hunger was measured before the manipulation, rather than after. Almonds were presented as the healthy choice instead of fresh food to ensure uniformity of taste, as fresh food is more likely to exhibit taste variations that may introduce an element of noise that influences the quantity of healthy food participants consume.

3.1. Method

3.1.1. Participants

Ninety-seven first year undergraduates (93 female, M_{age} = 20.87, SD = 4.46) from a Belgian university volunteered in exchange for course credits. Given that there was no prior comparable effect size that we could use to calculate the number of participants needed for our study, the number of participants was determined by how many could be recruited in the period from when the experiment started to when all experiments were closed to participants for the semester.

3.1.2. Design

The design comprised of a between-participant factor of condition with 3 levels (sensory imagery, decentering, control) × within-participant variable of food type with 2 levels (healthy vs. unhealthy food). Hunger, restrained eating, emotional eating and BMI were measured as continuous moderators.

3.1.3. Procedure

Participants performed the experiment in a laboratory. After giving informed consent and their demographic information, they performed a series of computer tasks that were programmed using E-prime. First, all participants completed a mood scale called the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), in which two items measuring their level of hunger were embedded ("At this moment, I feel full", "At this moment, I feel hungry", with the response options ranging from 1 = Not at all, to 5 = Extremely). However, we only analysed responses to the two items measuring hunger, (α = 0.70, with one question reverse coded).

Then the computer program randomly assigned them to one of the three mindset conditions, which was exactly the same as that in Experiment 1. Following this, participants performed a bogus taste test. They were presented with one bowl of M&Ms and one bowl of almonds, along with a glass of water. They were asked to take as much of each food as they liked (with serving spoons, on a paper plate), and to rate the food on various dimensions (sweet, salty, bitter, crunchy, palatable, pleasant), on a scale of 1 (not at all) to 7 (very much so). The reliability of the last two questions was α = 0.89 for M&Ms and α = 0.92 for almonds.

Participants then completed the restrained eating subscale (α = 0.73) of the DEBQ, and the emotional eating scale (α = 0.86) of the Three-Factor Eating Questionnaire (21-item version). As in Experiment 1, two attentional check questions were included in the task. As a manipulation check, participants rated how healthy they thought M&Ms and almonds were, on a scale of 1 (*Not at all healthy*) to 7 (*Very healthy*). Participants' height and weight were measured. Finally, they underwent the same funnel debriefing procedure as in Experiment 1.

Three participants were excluded for failing multiple attention check questions, one was excluded because s/he had a nut allergy and thus could not participate in the taste test, one was excluded because part of the data was not recorded for that participant, and data from two participants were excluded because they guessed the purpose of the study.

3.2. Results

Participants considered M&Ms and almonds to be equally appetising ($M_{M\&Ms}$ = 5.78, SD = 1.41; $M_{almonds}$ = 5.59, SD = 1.52), $t(89)$ = 0.83, p = .41, d = 0.09). We relied on a Bayesian analysis to test the null hypothesis that were no differences in perceived appetitiveness between the two types of food. As before, this analysis was conducted using Dienes' Bayesian calculator. Our alternate model specified a half-normal distribution of effect sizes centered on zero. This comparison revealed a Bayes factor of 0.22, supporting the null hypothesis.

Table 3
Descriptive statistics of Experiment 2. SDs are in parentheses.

	Overall mean (N = 90)	Sensory (N = 30)	Decentering (N = 33)	Control (N = 27)
Hunger	3.69 (0.96)	3.62 (0.90)	3.70 (0.92)	3.76 (1.10)
Restrained Eating	2.78 (0.80)	2.59 (0.82)	2.87 (0.83)	2.90 (0.75)
Emotional Eating	3.02 (0.96)	3.01 (0.83)	3.04 (1.03)	3.02 (1.03)
BMI	23.54 (3.88)	23.15 (3.88)	22.69 (2.37)	25.00 (4.94)
M&Ms consumed (g)	5.66 (6.10)	5.90 (5.94)	5.39 (3.70)	5.70 (8.42)
Almonds consumed (g)	1.49 (4.28)	3.90 (4.33)	4.88 (3.89)	4.44 (4.75)
M&M appetizingness	5.78 (1.41)	5.55 (1.73)	5.74 (1.51)	5.87 (1.38)
Almond appetizingness	5.59 (1.52)	5.50 (1.47)	5.55 (2.11)	5.50 (1.623)

Note. SDs are in parentheses.

Participants also considered almonds to be healthier than M&Ms ($M_{M\&Ms}$ = 1.68, SD = 0.83; $M_{almonds}$ = 5.60, SD = 1.80), $t(89)$ = 25.57, p = .00, d = 2.68). The descriptive statistics of Experiment 2 are shown in Table 3.

We ran a series of hierarchical linear regressions with nested orthogonal condition contrasts (experimental conditions vs. control; sensory imagery vs. decentering condition). Due to the relatively high number of predictors for the sample size, we first assessed the collinearity of the covariates through analyses of bivariate correlations, ($r \leq 0.29$) and VIF values ($\leq$1.13). These results suggest that the variables were not highly correlated with each other, and thus did not pose a major threat to the power of the study.[4]

However, it is possible that the predictor-sample ratio may pose a problem in terms model overfitting, which can occur when estimating too many parameters from a sample that is too small. To address this issue, we conducted a series of regressions with just one covariate and one related interaction term per model.[5] The results of this are presented in Table 4 (for hunger), Table 5 (for BMI), Table 6 (for restrained eating), and Table 7 (for emotional eating).

As shown in Table 4, there was a main effect of hunger on M&M consumption, ($t(89)$ = 1.97, 95% CI [−0.01, 2.65], p = .05), indicating that hungrier participants ate more M&Ms.

The effect of hunger interacted with the contrast between the experimental and control conditions, ($t(89)$ = −1.88, 95% CI [−1.75, 0.05], p = .06). Simple slopes analyses showed that although hungrier participants ate more M&Ms in the control condition than the experimental conditions, this effect was not significant (B = 0.88, $t(89)$ = 1.33, p = .19). Less hungry participants ate more M&Ms when they were in the experimental conditions than in the control condition, but this effect was also not quite significant (B = −0.83, $t(89)$ = −1.29, p = .20). Fig. 5 depicts the quantity of M&Ms participants ate at high and low levels of hunger.

The was also an interaction between emotional eating and the contrast between the experimental and control conditions ($t(89)$ = −1.92, 95% CI [−1.86, 0.03], p = .06). Simple slopes analyses showed that participants who were low in emotional eating ate more M&Ms when they were in the experimental conditions than when they were in the control condition, but this effect was not significant (B = 0.90, $t(89)$ = 1.34, p = .19). This pattern was reversed when participants were high in emotional eating, however, with participants eating more in the control than experimental conditions, although again, this effect was not sigificant (B = −0.93, $t(89)$ = −1.40, p = .17). The quantity of M&M consumed at high and low levels of emotional eating is shown in Fig. 6.

There were no significant effects for almond consumption.

3.3. Discussion

In Experiment 2 participants who were hungry and high in emotional eating consumed less in the sensory imagery and decentering conditions compared to the control condition. That is, although increased hunger and emotional eating induced participants to eat both more unhealthy and healthy food in the control condition, sensory imagery and decentering appeared to counteract these influences. These results support our hypothesis and the previous literature (Papies

Table 4
Standardised regression coefficients in Experiment 2 with hunger as a covariate (unstandardised coefficients, standard error in parentheses).

		M&M consumption *B*	Almond consumption *B*
Step 1	Hunger	1.32 (−0.01, 2.65)*	0.15 (−0.77, 1.07)
	Experimental vs. Control	0.03 (−0.90, 0.95)	−0.16 (−0.80, 0.48)
	Sensory vs. Decentering	0.31 (−1.22, 1.83)	−0.44 (−1.50, 0.63)
	F	1.34	0.33
	R^2	0.05	0.01
Step 2	Hunger	1.15 (−.17, 2.48)	0.10 (−0.84, 1.03)
	Experimental vs. Control	0.04 (−0.88, 0.96)	−0.15 (−0.78, 0.49)
	Sensory vs. Decentering	0.24 (−1.26, 1.75)	−0.45 (−1.52, 0.62)
	Hunger x Experimental vs. Control	−0.85 (−1.75, 0.05)*	−0.14 (−0.76, 0.49)
	Hunger x Sensory vs. Decentering	−0.72 (−2.40, 0.97)	−0.57 (−1.77, 0.63)
	F	1.64	0.41
	R^2	0.09	0.02

Note. * p = .06. Including the interaction term in Step 2 renders associated main effects in the same step uninterpretable.

Table 5
Standardised regression coefficients in Experiment 2 with BMI as a covariate (unstandardised coefficients, standard error in parentheses).

		M&M consumption *B*	Almond consumption *B*
Step 1	BMI	0.18 (−0.16, 0.53)	0.11 (0.47, 0.50)
	Experimental vs. Control	0.11 (−1.34, 1.76)	0.04 (0.12, 0.34)
	Sensory vs. Decentering	0.21 (0.10, 0.77)	−0.11 (−0.57, 0.55)
	F	0.41	0.77
	R^2	0.09	0.04
	BMI	0.16 (−0.24, 0.56)	0.14 (0.15, 0.15)
	Experimental vs. Control	0.07 (−0.92, 1.05)	0.02 (0.07, 0.35)
	Sensory vs. Decentering	0.31 (−1.31, 1.92)	−0.11 (−0.53, 0.58)
	BMI x Experimental vs. Control	0.16 (−0.24, 0.56)	−0.10 (−0.07, 0.09)
	BMI x Sensory vs. Decentering	0.15 (−0.40, −0.70)	0.22 (0.34, 0.21)
	F	0.32	0.98
	R^2	0.17	0.12

Note. * p = .06. Including the interaction term in Step 2 renders associated main effects in the same step uninterpretable.

Table 6
Standardised regression coefficients in Experiment 2 with restrained eating as a covariate (unstandardised coefficients, standard error in parentheses).

		M&M consumption *B*	Almond consumption *B*
Step 1	Restraint	−0.94 (−2.57, 0.79)	0.11 (0.47, 0.50)
	Experimental vs. Control	−0.07 (−1.02, 0.87)	0.04 (0.12, 0.34)
	Sensory vs. Decentering	0.12 (−1.44, 1.68)	−0.11 (−0.57, 0.55)
	F	0.47	0.77
	R^2	0.02	0.04
Step 2	Restraint	−0.92(−2.60, 0.76)	0.05 (0.23, 0.52)
	Experimental vs. Control	−0.07 (−1.03, 0.90)	0.02 (0.07, 0.35)
	Sensory vs. Decentering	0.11 (−0.48, 1.70)	−0.11 (−0.53, 0.58)
	Restraint x Experimental vs. Control	−0.07 (−1.33, 1.18)	
	Restraint x Sensory vs. Decentering	−0.01 (−1.94, 1.92)	
	F	0.28	0.98
	R^2	0.02	0.12

Note. * p = .06. Including the interaction term in Step 2 renders associated main effects in the same step uninterpretable.

[4] In theory, the number of predictors could pose a problem in terms of estimation, but Monte Carlo studies suggests that the ratio of predictors to sample size in our case is sufficient (e.g., Austin & Steyerberg).

[5] When the results of these regressions were compared to a model in which all the covariates were included, the only difference found was that the effects became more significant, i.e., the p-values of the marginally significant effects decreased to p = .02 for both the interaction between hunger and the contrast between the experimental and control conditions, and for the interaction between emotional eating and the contrast between the experimental and control conditions.

Table 7
Standardised regression coefficients in Experiment 2 with emotional eating as a covariate (unstandardised coefficients, standard error in parentheses).

		M&M consumption *B*	Almond consumption *B*
Step 1	Emotional eating	0.99 (−0.36, 2.34)	0.11 (0.47, 0.50)
	Experimental vs. Control	−0.02 (−0.95, 0.92)	0.04 (0.12, 0.34)
	Sensory vs. Decentering	0.27 (−1.27, 1.80)	−0.11 (−0.57, 0.55)
	F	0.74	0.77
	R^2	0.03	0.04
Step 2	Emotional eating	1.10 (−0.26, 2.47)	0.05 (0.23, 0.52)
	Experimental vs. Control	−0.01 (−0.93, 0.91)	0.02 (0.07, 0.35)
	Sensory vs. Decentering	0.25 (−1.26, 1.76)	−0.11 (−0.53, 0.58)
	Emotional eating x Experimental vs. Control	−0.92 (−1.86, 0.03)*	−0.20 (−0.61, 0.35)
	Emotional eating x Sensory vs. Decentering	0.70 (−0.99, 2.39)	−0.13 (−0.73, 0.66)
	F	1.46	0.98
	R^2	0.08	0.12

Note. * $p = .06$. Including the interaction term in Step 2 renders associated main effects in the same step uninterpretable.

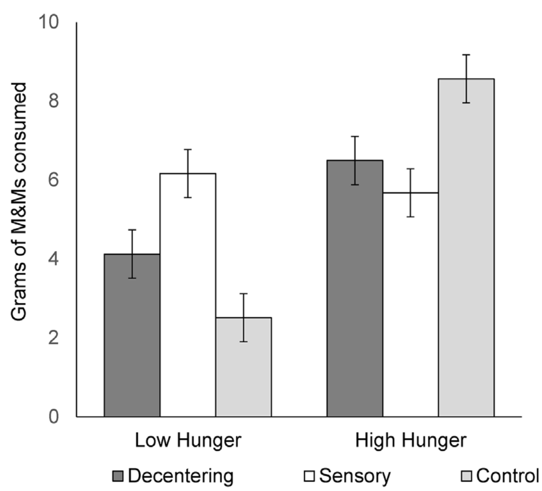

Fig. 5. The mean quantity of M&Ms consumed in each of the conditions in Experiment 2 at values 1 SD below (low hunger) and 1 SD above (high hunger) the mean level of hunger. Error bars represent prediction intervals, based on the standard error of the residuals.

et al., 2012, 2015) in demonstrating that sensory imagery and decentering reduces unhealthy eating in hungry participants. It also extends these results to healthy, hedonic food, and shows that similar effects pertain to emotional eating.

Unlike Papies et al. (2015; 2015), we did not find evidence that decentering increased the consumption of healthy food, although it must be noted that there was only one type of healthy food in Experiment 2, and it was considered to be similarly appetising as the unhealthy food, whereas in the studies of Papies et al. (2015; 2015) participants were presented with a range of healthy food, which were generally less hedonic than the unhealthy food.

These results differ in some ways to those of Experiment 1, where participants preferred a larger portion of healthy, tempting berries in the in the sensory condition compared to the decentering condition. Restrained eating did not have an effect on food consumption in Experiment 2, although it interacted with the different mindset conditions in Experiment 1 to affect willingness to eat unhealthy food and preferred portion size of such food. Moreover, BMI did not interact with the conditions to influence food consumption of healthy foods in

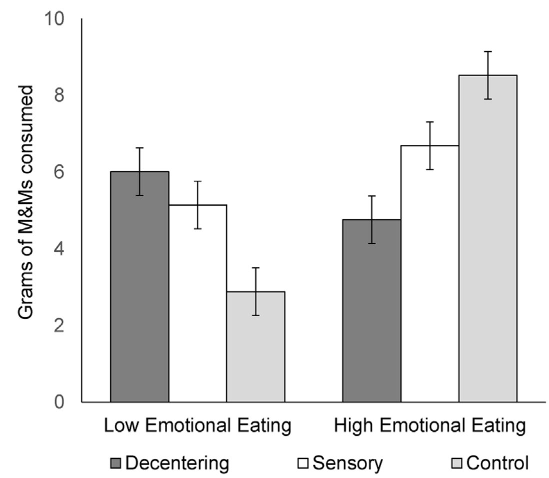

Fig. 6. The mean quantity of M&Ms consumed in each of the conditions in Experiment 2 at values 1 SD below (low emotional eating) and 1 SD above (high emotional eating) the mean level of emotional eating. Error bars represent prediction intervals.

Experiment 2, although it did in Experiment 1. These discrepancies may be due to several differences between the two studies, which will be discussed below.

4. General discussion

The aim of the present research was to compare the effects of sensory imagery and the decentering dimension of mindfulness on eating behaviour, in terms of individuals' willingness to eat healthy and unhealthy food (Experiment 1), and their actual consumption of such food (Experiment 2). We first predicted that hungrier participants in both the sensory and decentering conditions would show less preference for/less consumption of hedonic, unhealthy food compared to the control condition, but that this effect would be reduced for less hungry participants. Our prediction was supported in Experiment 2 with actual food consumption, and extended to the consumption of healthier food (i.e. almonds). These results suggest that sensory imagery and decentering operate on the hedonic, rather than the healthy aspects of food. No such effect was found for hypothetical food consumption in Experiment 1, with the only effect of hunger being that hungrier participants preferred a larger portion of berries in the sensory compared to the decentering condition. The results of Experiment 2 replicate that of previous research in showing that both the sensory and decentering conditions reduced the consumption of unhealthy food when participants were hungry compared to the control condition (Arch et al., 2016 examined only hungry participants; Cornil & Chandon, 2016; Papies et al., 2012, 2015). This pattern of results was also extended to emotional eating, which was not measured in their studies, but which represents another drive towards consuming tempting, often unhealthy, foods. Taken together, our results suggest that the mechanisms underlying sensory imagery and decentering differ between actual and hypothetical food consumption.

Based on the findings obtained by Cornil and Chandon (2016), we also predicted the effect of sensory imagery should lead participants to prefer smaller portions compared to the control condition in unrestrained eaters only. Instead, we found an interaction between restrained eating and the comparison contrast between sensory imagery and decentering in Experiment 1. Contrary to expectations, low-restrained eaters preferred a larger portion of chocolate cake in the sensory condition compared to the decentering condition, but this effect was reversed amongst high-restrained eaters. A similar effect was also found for willingness to eat healthy deserts. These results suggest that sensory imagery and decentering affect people's approach tendencies towards unhealthy, hedonic food in different ways.

We also examined whether participant BMI would moderate the effect of the mindset manipulations on food preferences. However, the only effect found was in Experiment 1, with participants with a lower BMI preferring a smaller portion of berries in the experimental conditions than the control conditions, and this effect being reduced amongst those with a higher BMI. This result is somewhat consistent with Cornil and Chandon (2016)'s finding that sensory imagery sometimes leads to greater reductions on preferred portion size amongst low BMI participants.

One difference between Experiments 1 and 2 was that hungrier participants preferred a larger portion of healthy berries in the sensory condition in Experiment 1 than in the decentering condition, but in Experiment 2 hungrier participants ate more healthy almonds in the control compared to the experimental conditions. Although almonds and berries were considered to be equally hedonic to their unhealthy counterparts, and both were considered to be healthier than the unhealthy comparison, they also differ in their ability to satiate participants. Studies show that high fat, energy-dense foods induce satiety at a lower rate than do lower calorie foods, leading people to eat more high-calorie foods (Rolls et al., 1994; Williams, Roe, & Rolls, 2014). Because almonds have a higher fat content than do berries (49g/100g – mostly unsaturated vs 0.3g/100g respectively), participants may have been inclined to eat more almonds than berries in the control conditions compared to the experimental conditions for this reason.

The different results between Experiments 1 and 2 may be further due to the fact that Experiment 1 examined hypothetical food consumption online, whereas Experiment 2 examined actual food consumption in a lab setting, and these two contexts may be influenced by different factors. However it is unlikely that the difference between hypothetical and actual food consumption accounts for these results, given that Papies et al. (2015) and Cornil and Chandon (2016) both found similar effects between studies using hypothetical and real food consumption, and b). However, the real food consumption task of Papies and colleagues and Cornil and Chandon did not require participants to perform a taste test, as our Experiment 2 did, and thus it may be that how people consume food during a taste test differs from how they consume food in other contexts. Given the prevalence of the taste test paradigm (e.g., Adams & Leary, 2007; Arch et al., 2016; Guerrieri, Nederkoorn, & Jansen, 2008; Hooper et al., 2012; Werthmann et al., 2011), future research is needed to examine how consumption during a taste test compares to consumption within more naturalistic eating and food decision contexts such as menu planning, grocery shopping, and buffet consumption.

It is also unlikely that the difference between the online and laboratory settings between Experiments 1 and 2 may account for the different results, given that Cornil and Chandon (2016) found similar results between their sensory imagery studies conducted online and in the laboratory. Although Papies et al. did not investigate the effects of decentering on food-related decisions online, a meta-analysis by Spijkerman Pots, and Bohlmeijer (2016) on the effectiveness of online mindfulness-based interventions in improving mental health revealed the such interventions have a small-moderate positive impact on mental health, suggesting that mindfulness itself can be successfully induced online.

It is interesting to note that restrained eating was differentially affected by sensory imagery and decentering in Experiment 1 but not Experiment 2. In comparison to previous research, Papies et al. (2012; 2015) did not find any effects of dietary motivation, whereas Cornil and Chandon (2016) found a slight tendency for sensory imagery to lead dieters to choose marginally larger portions, although this effect was not consistent across studies. Taken together, these results suggest that the effects of dietary restraint on sensory imagery and decentering are not robust. This lack of consistency may be due to the fact that dieters have conflicting associations with palatable, unhealthy food. On the one hand, they consider palatable food to be highly rewarding, and the sight and smell of such food can trigger cravings and overeating (Fedoroff, Polivy, & Herman, 1997, 2003; Rogers & Hill, 1989). On the other hand, they consider unhealthy food to be a threat to their goal of weight control, and thus have negative associations towards such food (Papies, Stroebe, & Aarts, 2009). The extent to which these competing associations influence eating behavior in dieters has been shown to depend on, among other things, their self-regulatory resources, with dieters eating more when they have fewer regulatory resources, such as when they are emotionally engaged (Hofmann, Rauch, & Gawronski, 2007). Because Experiment 1 did not require participants to consume food whereas Experiment 2 did, it is likely that the latter study required more regulatory resources, and invoked greater approach tendencies than the former study, which may have overshadowed the effect of restrained eating that was found in Experiment 1.

4.1. Underlying mechanisms of sensory imagery and decentering

Experiment 1 showed that sensory imagery increases approach tendencies towards hedonic healthy food in hungry participants and hedonic unhealthy food in low restrained eaters, compared to decentering. By contrast, it appears to reduce such tendencies for those who have a dieting goal. Given that previous studies (Coelho et al., 2009; Fishbach et al., 2003) show that tempting food stimuli can activate a dieting goal in restrained eaters, this suggests that sensory imagery may operate by enhancing the tempting qualities of food representations, thereby increasing approach tendencies in those for whom there are no motivational barriers to consuming such food, and triggering inhibitory tendencies in those who aim to avoid such foods.

Decentering may have the opposite effect by encouraging people to take distance from their subjective reactions to hedonic food stimuli, thereby making the food seem less tempting. The resulting food representations are less likely to incite approach tendencies for unrestrained eaters, but are also less likely to activate dietary goals amongst high restrained eaters.

However, it appears that sensory imagery and decentering have comparable effects on actual food consumption, with both serving to desensitize individuals to the effects of hunger and emotional eating. Given that hunger and emotional eating are both internal drives towards consumption, it may be that the mindset conditions reduced the effect of these drives by diverting participants' attention away from their internal motivations for consumption. In the sensory condition, this is likely to have occurred through participants focusing on the sensory qualities of external representations of food, which requires drawing on their past experiences with such food, rather than thinking about their current internal states. In the decentering condition, this is likely to have occurred through participants distancing themselves from their subjective reactions towards the food, thereby reducing their engagement with their internal states. Future research may investigate whether decentering interacts with restrained eating by actually reducing the accessibility of the dieting goal in restrained eaters, for example, by examining whether it reduces reaction times on a lexical decision task with diet-related words (e.g., Fishbach et al., 2003, Experiment 5).

The question then becomes, why do sensory imagery and decentering have different effects for consumption intentions (Experiment 1) versus consumption behaviour (Experiment 2)? Based on the preceding analysis, it would seem that the change in food representations brought about by these mindset manipulations influences consumption intentions to a greater degree than actual consumption. To the extent that representations inform attitudes (Conrey & Smith, 2007), this conclusion is consistent with previous research showing that the relationship between attitudes and intentions is stronger than that between attitudes and behaviour (Kim & Hunter, 1993). This may also explain why the intention-related outcomes of Experiment 1 were more sensitive to individual differences related to goal intentions, namely dietary restraint, then they were in Experiment 2.

4.2. Limitations

One limitation of our research is that the sample tested in Experiment 2 was overwhelmingly female, which was due entirely to characteristics of the population we had access to (i.e., first-year psychology students). However, Cornil and Chandon (2016), found comparable results with an exclusively female sample (Experiment 4), as they did with mixed sex samples, suggesting that sex does not moderate the effects of sensory immersion. Furthermore, other experiments investigating the interaction between sex and mindfulness interventions do not find any effects of sex (Greeson et al., 2015; Katz & Toner, 2013). Another limitation is that we did not test participants with a wide variety of different foods, which may imply that the results found could be food-specific. However, this limitation also applies to the research of Cornil and Chandon, and is partly due to the fact that we replicated their portion size paradigm in Experiment 1, and partly due to the nature of the taste test in Experiment 2, where asking participants to taste a wide range of foods may have introduced noise related to satiety-specificity. Future research may examine whether the effects of sensory imagery and decentering found here apply to other types of food, including those in which only the perception of healthiness is manipulated (e.g., Irmak, Vallen, & Robinson, 2011; Raghunathan, Naylor, & Hoyer, 2006).

5. Conclusion

Across two studies, we compared the effects of food-related sensory imagery and decentering on the preference for (Experiment 1) and consumption of (Experiment 2) hedonic healthy and unhealthy food. Although sensory imagery and decentering had largely different effects for preferences towards healthy and unhealthy foods, they had comparable effects on the consumption of both types of foods, serving to reduce the effects of consumption in participants affected by hunger and emotional eating. These results suggest that two potential mechanisms through which sensory imagery and decentering can influence hypothetical and actual consumption – either through changing individuals' momentary food representations, and/or by desensitising them to internal drives to consumption. The extent to which these two mechanisms influence food-related outcomes seems to depend on the nature of the outcome (e.g., whether it is related to hypothetical vs. actual consumption) and pre-existing intentions and internal drives related to consumption. While sensory imagery and decentering are based on different mechanisms that influence hypothetical consumption differently, they produce similar results when it comes to the actual consumption of hedonic food, regardless of how healthy the food is.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.appet.2018.08.013.

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