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Body and Mind: Mindfulness Helps Consumers to Compensate for Prior Food Intake by Enhancing the Responsiveness to Physiological Cues

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External cues regularly override physiological cues in food consumption resulting in mindless eating. In a series of experiments, this study shows that mindfulness, an enhanced attention state, improves consumers' reliance on physiological cues across consumption episodes. Consumers who are chronically high in mindfulness (study 1) or who receive a short mindfulness training that focuses attention on the body (study 2) compensate more for previous food intake in their subsequent consumption. Moreover, after a mindful body meditation, consumers are more aware of physiological cues that develop after consumption (study 3), rather than of the amount they have previously eaten (study 4). Furthermore, we argue and show that the focus of mindfulness matters: mindfulness trainings that focus attention on the environment or on the body similarly elicit state mindfulness, but only mindful attention with a focus on the body stimulates compensation for previous consumption and awareness of satiety cues. Finally, practicing mindfulness and specifically paying mindful attention to body sensations is related to a more constant body weight in a sample of the general population (study 5).

Keywords: mindfulness, food, consumption, compensation, hunger, satiety

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The human body is equipped with a complex homeostatic feedback system to regulate food intake. However, external cues in the eating environment regularly override physiological hunger and satiety cues. For example, consumers eat more when served bigger portions (Wansink and Park 2001), when others eat more (Hetherington et al. 2006), and when food products have low-fat labels (Wansink and Chandon 2006). These findings have led scholars to characterize food consumption as *mindless eating* and to conclude that attention to physiological hunger and satiety cues is easily offset by cues in the environment (Herman and Polivy 2005; Wansink 2010). Yet whereas it is well known that consumers often fail to attend to physiological cues in their eating behavior, far less is known about solutions to help consumers be more attentive to physiological cues. If mindlessness is related to consumers paying little attention to internal hunger

and satiety cues, could mindfulness lead them to rely more on these internal physiological cues?

Mindfulness has been defined as a state of “enhanced attention to and open awareness of current experience or present reality” (Brown and Ryan 2003, 822). Mindfulness is considered a personality trait but can also be trained, and such trainings are offered at numerous centers worldwide. Alongside the widespread prevalence of mindfulness in the popular media, benefits of mindfulness have received support in scientific research. Mindfulness has been associated with a range of beneficial psychological health outcomes, such as treating symptoms of depression, anxiety disorder, and pain (Brown, Ryan, and Creswell 2007), as well as reducing binge eating, emotional eating, and intrusive thoughts about food (May et al. 2010; Woolhouse, Knowles, and Crafti 2012). However, most of these studies have been conducted in clinical contexts and are part of larger long-term intervention programs or targeted toward individuals specifically trying to lose weight. This makes it difficult to determine whether the effects can be attributed to mindfulness specifically, and whether the benefits of mindfulness generalize to the population at large.

In the current study, we argue that mindfulness can improve responsiveness to internal hunger and satiety cues, based on its ability to foster an enhanced state of attention (Jha, Krompinger, and Baime 2007). Mindfulness might also influence consumption directly (eating less when mindful), but in this study, we are interested in the effect of mindfulness on enhancing compensation for prior food consumption (eating less when full and more when hungry), rather than its effect on consumption amount per se. We propose that even a short exposure to a mindfulness training can enhance consumers’ access to hunger and satiety cues, and that this is not limited to clinical samples or individuals who are trying to lose weight but occurs for consumers in general. Furthermore, the current study distinguishes between different foci of mindful attention. Trainings of mindfulness vary considerably in how they teach individuals to reach a state of mindfulness, through focusing attention on bodily sensations, stimuli in the environment, or on both simultaneously (Bishop et al. 2004). Because previous research has not distinguished different foci of mindfulness, it is not clear whether observed effects should be attributed to a general mindfulness effect or whether effects depend on the specific focus of the mindfulness training. We argue and show that not mindful attention per se, but mindful attention to aspects of the body fosters awareness and reliance on hunger and satiety cues.

Hunger and satiety cues affect within-meal consumption by signaling when to stop eating but also, and perhaps more importantly, can influence subsequent consumption by signaling how much to eat at a later point in time. Responsiveness to these cues indicates how well consumers compensate for previous consumption. This does

not necessarily mean consuming less, but rather regulating food intake in such a way that previous consumption is taken into account. This is important because incidental overconsumption may not be harmful when consumers are able to compensate. Compensating across meals can help consumers in attaining a constant energy intake and maintaining a healthy body weight. The current study aims to show that mindfulness facilitates the awareness of hunger and satiety cues, and enables consumers to compensate for previous food intake, both for mindfulness as a trait and for state-induced mindfulness.

PHYSIOLOGICAL CUES AND COMPENSATION IN FOOD CONSUMPTION

Ultimately, not single consumption episodes but consumption patterns made up of multiple consumption moments determine health outcomes. Many consumers balance their food intake from one meal to the next, as evidenced by the large prevalence of negative carryover effects in caloric intake, specifically within the course of a day (Khare and Inman 2009). Support for the idea that consumers balance consumption by making conscious mental accounts of food intake comes from studies showing that distracting people during consumption reduces their memory of what they have eaten and increases subsequent consumption (Higgs and Woodward 2009; Ogden et al. 2013). Besides such a cognitive process of compensation, individuals can also compensate by relying on physiological hunger and satiety cues that develop after consumption. The extent to which individuals are able to identify and respond to hunger and satiety cues is a critical determinant of their susceptibility to gain weight (Blundell et al. 2005; Cornier et al. 2004; Wansink, Payne, and Chandon 2007).

Given the benefits of awareness and responsiveness to physiological cues, it is important to know when people rely on these cues in food consumption. Previous studies on individuals’ baseline ability to identify and rely on physiological cues have produced mixed findings. Some studies find that consumers compensate for additional (covertly added) calories in subsequent consumption (McKiernan et al. 2009), whereas other studies conclude that internal compensatory mechanisms are weak (Kral, Roe, and Rolls 2004; Levitsky 2005). Relatively little is known on how compensation behavior can be enhanced. One state that can make individuals unsuccessful at compensating for previous consumption is a state of distraction. Distraction can interfere with memory formation of previous consumption but also interferes with the awareness of physiological hunger and satiety cues. For example, distracted consumers are less able to compensate for the caloric content of a previously consumed drink that is covertly manipulated to contain either few or many calories

(Bellissimo et al. 2007). This suggests that attention plays an important role in the awareness and reliance on hunger and satiety cues.

Individuals may also chronically be more or less responsive to hunger and satiety cues. A personality trait that has frequently been associated with a failure to compensate is restrained eating, a form of constant but often unsuccessful dieting (Herman and Mack 1975; Scott et al. 2008). Restrained eaters generally eat more rather than less after a prior consumption (Herman and Mack 1975). In contrast, individuals who engage in regular exercise are better at compensating for previous consumption (Long, Hart, and Morgan 2002). Whereas the precise mechanisms underlying restrained eaters' poor and exercisers' superior compensation for previous consumption are unclear, it is striking that these individual difference variables are related to different amounts of attention that these consumers pay to bodily cues. Restrained eaters, in order to keep with their dieting goal, actively try to ignore hunger cues. Continuously overriding these cues can make them less sensitive to body cues (Herman and Polivy 1980). Indeed, several types of disordered eating behavior have been shown to be related to paying little attention to the body (Spoor et al. 2005). In contrast, exercisers benefit from paying attention to internal body cues because it increases their performance (Masters and Ogles 1998). During physical exercise, attention has been found to switch to internal body sensations, in particular during more vigorous exercise (Hutchinson and Tenenbaum 2007). It is plausible, then, that for individuals who engage in regular exercise, body cues are more accessible.

Even though lifestyle differences may account for differences in compensatory behavior of restrained eaters and exercisers, these findings indicate that attention to body sensations could possibly help consumers respond to hunger and satiety cues, through an enhanced awareness of these cues. The area of mindfulness is concerned with reaching a state of enhanced attention, often through focusing on the body.

MINDFULNESS

Mindfulness has been defined as an enhanced attention to and open nonjudgmental awareness of what is going on at the present moment, and it is often described as a feeling of being fully present in the here and now (Brown and Ryan 2003). It has its roots in Buddhist traditions and is most often trained through meditation. Mindfulness also varies among individuals naturally, irrespective of any form of training (Brown and Ryan 2003). It has been conceptualized both as a unidimensional construct consisting of an open attention and awareness of what is taking place in the present moment (Brown and Ryan 2003; Petter et al. 2013) as well as a multifaceted construct consisting of a set

of skills (Baer, Smith, and Allen 2004). These skills typically include the ability to observe, notice, and attend to present-moment stimuli, to describe these stimuli, to be able to focus on one activity with full undivided attention, and to refrain from judging or evaluating present-moment experience (Baer, Smith, and Allen 2004). Other authors have emphasized the attention toward present-moment experiences and the adoption of a nonjudgmental stance toward these experiences as the main elements of mindfulness (Bishop et al. 2004). It is also suggested that a focus on present experiences inhibits elaborated, evaluative thinking about these experiences (Petter et al. 2013; Tops et al. 2014), and acceptance could thus be considered subsumed in the construct of present-centered attention. Overall, scholars agree that attention to present-moment experience is at the core of the mindfulness construct, and practices strengthening attentional focus form the basis of nearly all mindfulness practices.

Distinguishing Mindfulness from Self-Awareness and Self-Control

Mindfulness is characterized by the quality of awareness rather than by its content, and in this way it is distinct from constructs as self-awareness or self-reflection. Whereas both self-awareness and mindfulness involve self-observation, self-awareness concerns understanding and reflecting on the self rather than simply observing what is taking place (Bishop et al. 2004). Mindfulness operates in a sensory-perceptual mode, attending to information coming from the senses, and can be contrasted with a more conceptual mode involving higher order processes such as planning, analyzing, and judging (Bahl et al. 2013). Similarly, mindfulness has been described as a type of "experiential awareness" that involves experiencing the self in a bottom-up fashion, triggered by features in the environment that take place in the present (Damasio 1994). Self-awareness, in contrast, is characterized as a type of conceptual knowledge involving internal schemas of the self as an abstract object, formed by self-reflection and by linking experiences across time (Tops et al. 2014). In support, measures of mindfulness are unrelated to measures of self-awareness and negatively related to public self-awareness (Brown and Ryan 2003).

Mindfulness has also been related to the concept of self-control, or the ability to forgo one's immediate desires in favor of (longer term) goals. For instance, a brief mindfulness training can counteract the effects of self-control depletion on subsequent self-regulation (Friese, Messner, and Schaffner 2012). We therefore consider mindfulness as a strategy to enhance self-control rather than as similar constructs. Most strategies to increase self-control involve changing or inhibiting thoughts, emotions, or behaviors in response to tempting stimuli (e.g., reappraisal, suppression), after desires or cravings have been fully developed.

Instead, mindfulness is not concerned with acting on thoughts or sensations but simply with observing them, and it can halt the development of cravings (Papies et al. forthcoming).

Mindfulness and Eating

Studies on food intake have recently shown that mindfulness-based interventions can reduce binge eating (Courbasson, Nishikawa, and Shapira 2011; Dalen et al. 2010; Tapper et al. 2009; Woolhouse et al. 2012) and emotional and external eating (Alberts, Thewissen, and Raes 2012; Daubenmier et al. 2011; Woolhouse et al. 2012). Furthermore, mindfulness interventions can decrease body weight (Dalen et al. 2010), stabilize body weight (Daubenmier et al. 2011), and reduce weight gain compared to a control group (Timmerman and Brown 2012), although other studies have also found no effects on body weight (Kristeller, Wolever, and Sheets 2013).

In many of these studies, mindfulness exercises are part of larger intervention programs and combined with other therapeutic elements, which makes it difficult to ascertain what effect of the intervention can be attributed to mindfulness. Also, because many of these studies involve clinical populations or individuals who are trying to change problematic eating habits, it is likely that the accepting, nonjudgmental aspect of mindfulness is effective in training them to cope with problematic thoughts about food. For example, Lacille et al. (2014) showed that detachment from one's thoughts about food effectively reduces food cravings. Initial evidence suggests that also among nonclinical populations, mindfulness can change thoughts about food and more recently also eating behavior (Jordan et al. 2014). Practicing a short mindfulness exercise can prevent individuals from displaying approach reactions toward attractive foods (Papies, Barsalou, and Custers 2012) and from elaborating about food (Hamilton et al. 2013; May et al. 2010). This nonevaluative attention distinguishes mindful eating from restrained eating. Whereas restrained eaters focus on changing or suppressing their body sensations (with the risk of reducing awareness in the long run), mindfulness is concerned with nonevaluative observation of present-moment experiences.

Whereas most studies have focused on the accepting, nonjudgmental nature of mindfulness, far less attention has been paid to one of its core elements, its ability to enhance present-centered attention. The current study proposes that the ability of mindfulness to foster a mental state of focused attention is relevant for eating behavior and compensation in particular.

Mindfulness and Attention

Outside of clinical psychology, several studies have found support for mindfulness's claim that it enhances

attention regulation. Mindfulness training leads to more focused attention (Jha et al. 2007; Wenk-Sormaz 2005), increases the duration with which individuals can sustain attention (Valentine and Sweet 1999), and improves working memory (Jha et al. 2010; Mrazek et al. 2013). For example, a brief exposure to a mindfulness training leads to less interference in a Stroop task (Wenk-Sormaz 2005). Besides effects on general attention performance, mindfulness meditation is also specifically related to enhanced attention and awareness of body sensations. After mindfulness interventions, participants report increased awareness of body sensations such as temperature, itch, hunger, thirst, heartbeat, or breathing (Daubenmier et al. 2011). Neurological studies have found that mindfulness is related to the activation of brain areas involved in the awareness of body sensations (Farb et al. 2007; Holzel et al. 2011; Lazar et al. 2005). Importantly, one study suggested that mindfulness training is capable of reducing the perceptual threshold of subtle body sensations among novices: when people had to detect touch that was applied to their fingertips at near-threshold level, a short mindfulness training improved their performance (Mirams et al. 2013).

Given the role of mindful attention in the awareness of subtle body sensations and based on recent findings that the awareness of different types of body sensations are related (Herbert et al. 2012, 2013), we propose that mindfulness facilitates the awareness of physiological hunger and satiety cues, and subsequently enhances compensation behavior in food consumption. An additional issue we examine is whether the object of mindful attention matters. Whereas reaching a focused state of attention is the overarching goal of all mindfulness trainings, these trainings vary considerably in how they attempt to achieve this. Popular mindfulness meditation practices, such as the body scan and sitting meditation, guide individuals' attention along different parts of the body and train them to focus attention on their breathing (Kabat-Zinn 1990). Other mindfulness trainings emphasize focusing on external objects in the environment or on both internal and external sensations at the same time (Bishop et al. 2004). It is not clear whether a general mindfulness effect causes the range of observed beneficial outcomes or whether the focus of mindful attention needs to be aligned with the desired outcome. In the current study we therefore not only examine whether mindfulness can improve responsiveness to internal cues in food consumption but also whether the object of mindful attention matters.

In five studies, we examine the effects of mindfulness on food compensation. Chronic mindfulness, as a personality trait, is investigated in study 1. Next, study 2 examines state mindfulness elicited through short audio fragments of mindfulness meditation. This allows us to distinguish between mindfulness exercises directing attention to the body and those directing attention to the environment, and assess whether the focus of attention is

crucial. Next, we examine the proposed underlying process of accessibility of hunger and satiety cues (study 3) and rule out an alternative explanation based on enhanced recall of previous consumption (study 4). Finally, study 5 tests the longer term effects of chronic mindfulness on fluctuations in body weight.

STUDY 1

Study 1 tests our central prediction that mindfulness can enhance compensation for previous consumption in subsequent food intake. We use a preload paradigm, in which additional calories are covertly added to a milkshake in the condition with a large preload. This implies that participants are unaware of the caloric content and can only compensate by relying on the physiological cues that develop as a result of the preload. Trait mindfulness is measured as an individual difference variable. By assessing several facets of trait mindfulness (Observing, Describing, Acting with Awareness, and Acting without Judgment; Baer et al. 2004), we test our prediction that the awareness of present-moment experience (captured most closely by the observing component) helps consumers in compensating for previous consumption. Additionally, the effects of dietary restraint, trait self-control, and self-awareness on compensation are assessed to determine the unique contribution of mindfulness.

Method

Participants and Design. Participants were recruited around campus through flyers and randomly assigned to one of two preload conditions (low vs. high caloric content). They received a €6 gift voucher in return for participation. Ten participants were excluded from the data analysis because they did not consume the entire preload, and six participants were excluded due to errors in measuring food intake. This left 85 participants (30 men, 55 women; mean age 20.9 years) in the analysis.

Procedure. Sessions took place between 1:30 and 4:00 PM to minimize baseline differences in hunger feelings. Participants were told that the session involved a series of unrelated studies. The first part was described as a taste test of milkshakes. Participants were first asked to indicate their current feelings of hunger on 100-mm visual analog scales (VAS) (“How hungry are you at this moment?” “How full do you feel at this moment?” (0 = Not at all, 100 = Extremely; $\alpha = .77$). Participants were also asked to indicate whether they had lunch or engaged in sports before the experiment. They were then served a 300-ml milkshake and asked to finish it completely. Unbeknownst to them, the milkshake was either low caloric (215 kcal) or high caloric (534 kcal) (cf. Long et al. 2002). Both milkshakes contained equal amounts of skimmed yogurt,

vanilla flavor, and sugar. Both also contained skimmed milk, but in the high caloric milkshake part of the skimmed milk was replaced by full-fat cream. Participants rated the milkshake on liking, perceived healthiness, perceived caloric content, willingness to buy, and several sensory properties (sweetness, sourness, creaminess, mouth feel, ability to satiate) on a VAS (0 = Not at all, 100 = Extremely).

After a short filler task, trait measures of mindfulness, self-control, and public and private self-awareness were administered. In between these trait measures, participants were briefly asked about feelings of hunger and satiety using the same measures as at the start of the study. After a filler task in which participants watched a neutral video fragment, they received a second taste test. Participants were served two bowls of chocolate snacks (peanut M&Ms and a store brand of chocolate snacks similar in size to M&Ms), containing 80 and 45 g, respectively. They were free to take as many chocolates as they liked and rated the snacks on sweetness, crispiness, palatability, pleasant after-taste, and visual appeal (1 = Does not describe product at all, 7 = Describes product very well). Next, they rated neutral video fragments as filler tasks. The chocolate snacks were left with the participants while they proceeded to allow for more time for consumption. In the end participants were asked about their experience in mindfulness, rated their subjective health and pain experiences, and filled out demographics and a measure of restrained eating. After they had left, the remaining snacks were weighed to assess consumption.

Measures. Trait mindfulness was assessed with the Kentucky Inventory of Mindfulness Scale (KIMS; Baer et al. 2004), composed of four subscales assessing observing (e.g., “I notice changes in my body, such as whether my breathing slows down or speeds up”; 12 items; $\alpha = .79$), describing (e.g., “I am good at finding the words to describe my feelings”; 8 items; $\alpha = .90$), acting with awareness (e.g., “When I’m doing something I’m only focused on what I’m doing, nothing else”; 10 items; $\alpha = .77$) and acting without judgment (e.g., “I tell myself that I shouldn’t be thinking the way I’m thinking”; 9 items; $\alpha = .89$). Participants rated the extent to which each item is true for them (1 = Never/almost never true, 7 = Almost always/always true). In addition, the Mindful Attention Awareness Scale (MAAS) (Brown and Ryan 2003) was included as a trait measure of mindfulness. Full scales for these mindfulness traits and the other personality traits used in this study are available in the online appendix accompanying this article.

Three other personality traits were assessed: restrained eating, self-control, and self-consciousness. Restrained eating was measured with the relevant 10 item subscale of the Dutch Eating Behavior Questionnaire (DEBQ) (e.g., “How often do you try not to eat over the course of an evening, because you are dieting?” rated on 1 = Never, 5 = Very

often; $\alpha = .89$; van Strien et al. 1986). Self-control was measured using the Brief Self-Control Scale (BSCS; Tangney, Baumeister, and Boone 2004), a 13 item scale assessing dispositional self-control (e.g., "I am good at resisting temptation," rated on 1 = Not at all applicable to me to 7 = Very much applicable to me; $\alpha = .80$). Measures of public self-consciousness (7 items; e.g., "I'm concerned about the way I present myself"; $\alpha = .80$) and private self-consciousness (8 items; e.g., "I'm always trying to figure myself out"; $\alpha = .82$), both rated on 1 = Not at all applicable to me to 7 = Very much applicable to me, were taken from the two subscales of the self-consciousness scale (Fenigstein, Scheier, and Buss 1975).

Experience in mindfulness was assessed by asking, "To what extent do you have experience in mindfulness and/or meditation?" (1 = No experience at all, 7 = A lot of experience). The majority of participants had no or very little experience with mindfulness (1 or 2 on the scale). In analyses, this variable did not affect snack consumption or interact significantly with caloric content to predict snack consumption, and this variable is not reported on further.

Results

Baseline Hunger. The two caloric content conditions did not differ in baseline levels of hunger at the start of the experiment ($F(1, 83) = 0.30, p = .60$).

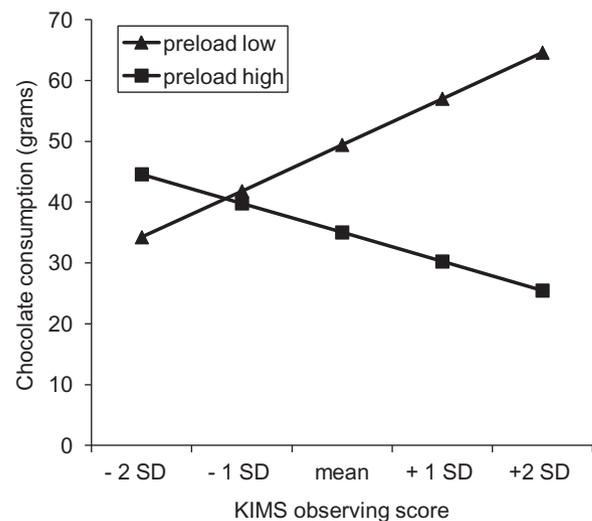
Snack Consumption. To examine the joint effects of caloric content and dispositional mindfulness on the amount of chocolate snacks that participants consumed, an ordinary least squares regression analysis was performed. Caloric content of the preload milkshake (coded $-1 =$ Low caloric, $1 =$ High caloric) and the subscales of the KIMS (observing, describing, acting with awareness, acting without judgment, all centered around its mean) were entered as independent variables. Because the observing subscale was central to our prediction, the interaction between the observing subscale and the caloric content condition was also entered. Gender of participants (coded $-1 =$ Male, $1 =$ Female), and restrained eating (centered around its mean) were included as covariates, and the amount of chocolate consumption (in grams) served as the dependent variable. The results show a main effect of gender on the amount of consumption ($t(76) = -3.63, p < .01, sr^2 = .12$); men consumed more ($M = 53.23$ g) than women ($M = 30.87$ g). Main effects also emerged for restrained eating ($t(76) = 2.23, p < .05, sr^2 = .05$) and the acting with awareness subscale of the KIMS ($t(76) = 2.28, p < .05, sr^2 = .05$). A higher score on restrained eating was associated with a larger amount of consumption ($\beta = .23$). Unexpectedly, the acting with awareness subscale also showed a positive relationship with amount of consumption ($\beta = .23$). No main effects were found for any of the other subscales of the KIMS (all $|t$'s $|$ less than .91, not

significant [NS]). A main effect was found for the caloric content of the preload ($t(76) = -2.29, p < .05, \beta = -.22, sr^2 = .05$), such that overall participants ate less after a high caloric preload ($M = 31.24$ g) compared to a low caloric preload ($M = 47.23$ g). This effect was further qualified by a (marginal) significant interaction with the observing subscale of the KIMS ($t(76) = -1.88, p = .06, sr^2 = .03$).

To examine the interaction between the caloric content of the preload and the mindfulness observing subscale more carefully, follow-up spotlight analyses were conducted (see also figure 1). The results showed that for participants who score higher on the observing subscale of the KIMS (1 standard deviation [SD] above the mean) the caloric content of the preload had an effect on their subsequent snack consumption ($\beta = -.41; t(76) = -2.99, p < .01, sr^2 = .08$), such that they consumed fewer snacks after a high caloric preload compared to a low caloric preload. For participants low in mindfulness (1 SD below the mean), the caloric content of the preload had no effect on later consumption ($t(76) = -.20, p = .84$). Additional analyses assessed consumption within each of the preload conditions, but regression lines of the observing subscale of KIMS were nonsignificant in both conditions. In separate regression analyses, we tested whether any of the other subscales interacted with caloric content in predicting amount of consumption, but this was not the case (all $|t$'s $|$ less than .96, NS). Also, in separate regression analyses it was tested whether restrained eating, trait self-control, and public and private self-awareness interacted with caloric content in predicting amount of consumption, but none of

FIGURE 1

AMOUNT OF CHOCOLATE CONSUMED AS A FUNCTION OF TRAIT OBSERVING MINDFULNESS (SCORE ON KIMS OBSERVING SUBSCALE) AND CALORIC CONTENT OF THE PRELOAD



these interactions were significant (all $|t$'s $|$ less than 1.53, NS).

We tentatively explored the effects of those items within the observing subscale that target attention to the body (6 items; $\alpha = .67$), attention to the environment (3 items; $\alpha = .72$) and attention to feelings (3 items; $\alpha = .69$). A marginal interaction effect appeared between caloric content and attention to the body (but not for attention to environment or feelings, assessed in separate analyses) such that for participants who paid more attention to their bodies, the caloric content of the preload affected later consumption ($t(78) = -1.75$, $p = .08$, $sr^2 = .03$). When correcting for restrained eating, this effect became nonsignificant. Still, this preliminary evidence suggests that the focus of attention may matter, and we examine this in more detail in study 2. The KIMS subscales did not affect hunger and satiety feelings after consumption of the preload.

Results for the MAAS for mindfulness showed that this scale is positively correlated with the acting with awareness and acting without judgment subscales of KIMS, and not significantly correlated with attention to the body, the subscale of interest. For a reflection on the MAAS, see the general discussion section.

Ratings of the Low and High Caloric Content Milkshakes. The low and high caloric milkshakes were similarly liked and were overall perceived to be similar in a range of sensory attributes (e.g., caloric content, creaminess, aftertaste, healthiness, satiating; all F 's less than .61). The two conditions only differed in perceived sweetness ($F(1, 81) = 5.82$, $p < .05$) and liquidity of the milkshake ($F(1, 81) = 6.20$, $p < .05$). The high caloric milkshake was perceived to be less liquid ($M = 55.73$) and less sweet ($M = 62.93$) than the low caloric milkshake (liquidity: $M = 67.18$; sweetness: $M = 71.1$). These ratings did not influence snack consumption, and including these as covariates did not change our pattern of results.

Discussion

These findings show that trait mindfulness, more specifically the component of mindfulness that relates to a present-centered awareness of experiences, is related to an enhanced responsiveness to satiety cues. Individuals who score high on this component of mindfulness adjust their subsequent consumption to the (covert) caloric content of what they have previously eaten, whereas individuals who score low do not. Moreover, findings indicate that these compensation effects cannot be explained by other traits such as self-control or self-awareness.

STUDY 2

Study 2 assesses whether a temporary state of mindfulness also leads to enhanced compensation for previous

consumption, through short audio fragments of mindfulness meditations. In study 1 we showed that specifically the focused attention aspect of mindfulness is crucial in compensation. In study 2, we further examine whether it matters *where* attention is focused. We therefore distinguish between two kinds of mindfulness instructions—instructions that focus attention on the body and instructions that focus attention on the environment—to distinguish between effects of mindful attention in general and a body-focused state of mindfulness.

Method

Participants and Design. Participants were randomly assigned to a 2 (Portion size preload: small vs. large) \times 3 (Mindfulness instructions: attention focus on body vs. attention focus on environment vs. control) between-subjects design. One participant who indicated not to have followed the experimenter's instructions regarding the audio fragments (score lower than four on a 7 point scale) was removed from the dataset. This left 117 students (37 men and 80 women; mean age 20.3 years). They received a €5 gift voucher for participation.

Procedure and Measures. Participants were seated in individual cubicles on adjustable chairs and asked to make sure their upper and lower legs made an angle of 90 degrees. At the outset of the study, they were asked about their current hunger feelings on a 7 point scale (1 item; 1 = Not at all hungry, 7 = Very hungry), whether they had breakfast and lunch or engaged in sports before the experiment. Participants then started what was described as an evaluation task of an audio fragment but was in fact the mindfulness manipulation. Depending on condition, they listened to an audio fragment on an individual MP3 player with instructions to focus attention on the body, instructions to focus attention on the environment around them, or a recorded short essay. In line with the cover story, participants evaluated the audio fragments on 7 point scales (1 = Not at all, 7 = Very much) in terms of how much they liked the fragments, it caught their interest, the difficulty of the instructions, and the length and pace of the fragments.

Next, participants proceeded with what was described as a taste test of either a snack-size Snickers (18 g, 91 calories) or a full-size Snickers (57 g, 287 calories). In both conditions the snack was unwrapped. Participants were required to finish the whole snack and to rate it on several dimensions (sweetness, taste, size, crunchiness, mouthfeel, aftertaste) on 7 point scales (1 = Does not describe product at all, 7 = Describes product very well). To allow for satiation to set in, they then filled out unrelated filler tasks for 20 minutes before proceeding with the second taste test. In between the filler tasks, a state version of the MAAS and the Positive Affect Negative Affect Schedule (PANAS; Watson, Clark, and Tellegen 1988) were administered.

Participants were served two bowls of two types of chocolate cookies (bite-size chocolate chip cookies and a type of very thin sliced chocolate-covered sweet chips) containing 60 g and 40 g of cookies, respectively, and were free to take as many as they would like. They rated the cookies on several dimensions, similar to the first taste test, and filled out neutral filler questionnaires for around 10 minutes, to allow for more time for consuming cookies. In the end, participants filled out demographic information (age, height, weight, and dieting status) and were thanked and paid. After participants had left, the remaining cookies were weighed to assess cookie consumption.

Mindfulness Instructions. The audio fragments (all around four minutes) were prepared in close cooperation with an experienced and practicing yoga teacher, who read out the instructions for all three conditions. The attention to the body condition combined aspects of often used mindfulness exercises such as sitting meditation and the body scan (Kabat-Zinn 1990). Participants were instructed to close their eyes and to put their hands on their upper legs. Their attention was slowly guided along different parts of their body (e.g., “Bring your attention to the spine. . . Become aware of your tailbone, in your thoughts go vertebra by vertebra upward along your spine”). Throughout participants were also made aware of their breathing and performed several simple exercises (e.g., “While you inhale, lift your toes up from the floor and while exhaling, put them back again”). In the attention to the environment condition, attention was slowly guided along objects in the surroundings, such as the chair participants were sitting on, objects on the table, and the partitioning between them and the next cubicle (e.g., “Focus your attention on the structure of the wood, on the color”). To help participants focus their attention on aspects of the surroundings, they were also asked to perform simple exercises (e.g., “Focus your attention on one stone of the wall, go up stone by stone”). In the control condition, participants listened to a short essay on tourism that had been recorded by the yoga instructor for the current study. The essay was written by a professional writer and has been broadcast on the radio.

The three audio fragments were pretested ($N = 66$), with participants answering general questions on mindfulness (e.g., “I was preoccupied with the past or the future”), awareness of the body (e.g., “I was aware of tensions in my body”; $\alpha = .84$) and awareness of the environment (e.g., “I noticed I paid a lot of attention to details in my surroundings”; $\alpha = .80$). As expected, both mindfulness audio fragments lead to increased levels of state mindfulness compared to the control condition ($p < .06$), while not significantly differing between themselves ($t(60) = -0.79$, $p = .44$). Additionally, participants were more aware of their body in the attention to body condition than the other two conditions ($p < .001$), and participants were more

aware of their environment in the attention to environment condition than the other two conditions ($p < .001$).

Results

Background. There were no differences in baseline feelings of hunger among conditions ($F(5, 107) = .67$, $p = .64$). Next, we examined the ratings of the audio fragments. The attention to body condition was rated as more interesting than the other conditions ($M_{\text{body}} = 4.25$, $M_{\text{environment}} = 1.97$, $M_{\text{control}} = 3.26$; $F(2, 114) = 23.30$, $p < .001$), and its instructions as harder to perform than the attention to environment condition ($M_{\text{body}} = 2.28$, $M_{\text{environment}} = 1.63$; $F(2, 114) = 23.67$, $p < .001$). There was a main effect of the audio fragments on experienced positive affect ($F(2, 110) = 3.39$, $p < .05$) but not on negative affect ($F(2, 110) = .60$, $p = .68$). We will examine whether these differences affect cookie consumption.

For the snack preload, no differences were found in any ratings of the small and large snacks (all $F(1, 115) < 0.94$, NS), with the expected exception of size ($F(1, 115) = 117.8$, $p < .001$). We also tested whether participants in the different mindfulness conditions perceived the size of the chocolate snack differently, but this was not the case ($F(2, 111) = .57$, $p = .57$).

Cookie Consumption. An analysis of variance (ANOVA) was performed with mindfulness instructions and portion size of the preload as independent variables and cookie consumption as the dependent variable. Gender was taken up as a covariate. Separate analyses tested whether gender interacted with our manipulations, but this was not the case. The results showed no main effects of the portion size of the preload ($F(1, 110) = 1.91$, $p = .17$), the mindfulness condition of participants ($F(2, 110) = 1.89$, $p = .16$), or gender ($F(1, 110) = 0.74$, $p = .39$). In line with our expectations, there was a significant portion size preload \times mindfulness interaction ($F(2, 110) = 3.14$, $p < .05$, $\eta^2_p = .05$). Follow-up simple effect analyses showed that the size of the preload affected cookie consumption in the attention to body condition: participants who had been served a large preload ate fewer cookies ($M = 26.9$ g) than participants who had been served a small preload ($M = 47.5$ g; $F(1, 110) = 7.77$, $p < .01$, $\eta^2_p = .07$). Portion size of preload did not significantly affect cookie consumption in the attention to environment condition ($F(1, 110) = 0.06$, $p = .80$) or in the control condition ($F(1, 110) = 0.34$, $p = .56$). Means are displayed in figure 2.

Furthermore, examining consumption within the small and large portion size preload conditions revealed that after a small preload, participants in the attention to body condition consumed more cookies than in the other two conditions ($M_{\text{body}} = 47.5$ g, $M_{\text{environment}} = 29.5$ g, $M_{\text{control}} = 34.6$ g; $F(2, 110) = 3.35$, $p < .05$, $\eta^2_p = .06$). In the large preload condition, there were no differences in

consumption across mindfulness conditions ($F(2, 110) = 1.66, p = .20$). Thus participants in the mindful body condition mainly compensated by eating more cookies after having consumed a small size preload.

To rule out that differences between the fragments in difficulty or interest or in the positive affect that was elicited were driving our effects, we conducted additional analyses with these variables as covariates. Difficulty of instructions positively affected cookie consumption, and interest in the fragment had a marginal effect, but their inclusion did not affect the interpretation of any other effects. Positive affect did not influence cookie consumption, and its inclusion did not influence the interaction effect. Thus these differences between fragments did not drive our findings.

Discussion

These results show that mindfulness improves compensation for previous consumption and that even a short mindfulness manipulation can lead individuals to adjust intake to previous consumption. It matters where attention is directed because only mindful attention to the body produces these results. In this study, mindful attention to the body leads people to consume more after a small portion size preload, rather than less after a large portion size preload. A potential reason for this asymmetry is that hunger and satiety signals are not equal in strength: satiety cues are less dominant than hunger cues (Jebb et al. 2006; Zheng et al. 2009). As a result, it is easier to sense and adjust for a decrease in calories in a diet than for an increase (Mattes, Pierce, and Friedman 1988). This is often attributed to an evolutionary advantage of strong hunger signals

during times of food scarcity (Zheng et al. 2009). We return to this issue in the general discussion section.

STUDY 3

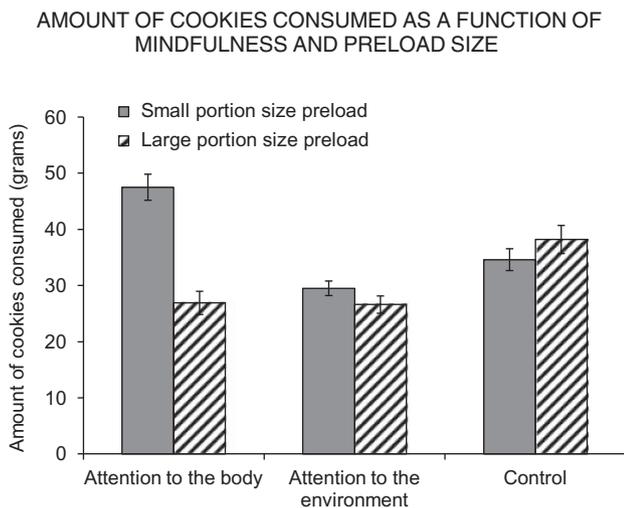
Study 3 tests our prediction that mindfulness enhances the awareness of physiological hunger and satiety cues that develop after consumption. In study 2 we only asked participants at the start of the experiment about their feelings of hunger and not again after their preload consumption because making participants very explicitly aware of this could interfere with their subsequent consumption. Therefore, in study 3, we examine the effects of mindfulness on the awareness of satiety feelings after different preloads. We further extend the findings of study 2 by using a different operationalization of the mindful attention to environment condition. In study 2 this condition focused participants' attention on the immediate surroundings of the lab, which may have been rather boring compared to focusing attention on the body. To remove this potential confound, a different audio fragment was used.

Method

Participants and Design. Participants were assigned to a 3 (Mindfulness condition: mindful attention to the body vs. mindful attention to the environment vs. control) \times 2 (Preload: low vs. high caloric content) between-subjects design. Eight participants did not completely consume the preload, and six participants indicated not to have followed the instructions (a score lower than four on a 7 point scale) and were therefore excluded from analyses. This left 117 participants (28 men, 89 women; mean age 21.0 years). Participants received a small monetary compensation.

Procedure and Measures. Participants first indicated baseline satiety feelings on a 100 mm VAS scale (e.g., "How hungry are you at this moment?") five items; $\alpha = .92$). Participants also indicated whether they had breakfast and lunch or engaged in sports before the experiment and filled out a trait measure of the MAAS. Mindfulness to the body and control condition were identical to the previous study, but a different mindful attention to environment condition was administered. The new fragment was equal in length to the other audio fragments and recorded by the same yoga teacher. In this condition, a photo frame with a picture displaying an idyllic grass hillside landscape and a sunset was placed on the table in front of the participant. In the audio fragment, attention was then guided along different aspects of the landscape (e.g., "Study the different tones of colors of the clouds"). A pretest ($N = 71$) confirmed that the modified attention to environment condition elicits similar

FIGURE 2



NOTE.—Error bars represent standard error of means.

levels of state mindfulness as the mindful attention to the body condition, and focuses attention on the environment specifically. Moreover, the two conditions did not significantly differ in the amount of pleasure and arousal that they elicited (abbreviated version of the pleasure, arousal, dominance (PAD) scale; Mehrabian and Russel 1974) or in ratings of boredom.

After rating the audio fragment on the same measures as in the previous study, participants proceeded with what was described as a taste test. They were served chocolate milk and a typical local winter treat, a type of spiced cookie filled with a rich sugar and almond paste. Participants consumed 200 ml of a light version of chocolate milk with skimmed milk and a small portion (31 g) of the cookie in the low caloric content condition (total 233 kcal) or 200 ml of a full-fat version of the same brand of chocolate milk together with a large portion of the same cookie (62.5 g) in the high caloric condition (total 448 kcal). Participants were unaware of the number of calories in the chocolate milk and cookie. They were required to finish the chocolate milk and cookie completely and to rate both on taste, sweetness, creaminess, and aftertaste. A neutral filler task of around 10 to 15 minutes followed, intended for satiation to set in. Afterward, participants again answered questions about hunger and satiety feelings (coded so that higher scores reflect higher perceived satiety; 5 items, $\alpha = .91$). Participants then provided demographic information (gender, age, weight, and height) and indicated whether they were currently dieting or practiced yoga. Finally, participants were probed for suspicion and filled the restrained eating subscale of the DEBQ (van Strien et al. 1986).

Results

Baseline Levels of Satiety. Despite random assignment to conditions, baseline levels of satiety were marginally different across conditions ($F(5, 111) = 2.23, p = .06$). Baseline levels of satiety were therefore controlled for in the analyses.

Satiety Feelings After Consumption of Preload. An ANOVA analysis was performed with mindfulness and preload as independent variables and satiety feelings after consumption as the dependent variable, controlling for baseline differences in satiety feelings at the start of the experiment. Gender was taken up as a covariate. Results showed that the preload condition had a significant effect: Participants who had been served a small preload subsequently reported to feel less full ($M = 62.44$) than participants who had been served a large preload ($M = 68.04; F(1, 109) = 12.75, p < .01, \eta^2_p = .11$). The results also showed a significant effect of gender ($F(1, 109) = 11.13, p < .01, \eta^2_p = .09$) with men feeling less full ($M = 59.86$) than women ($M = 66.90$) and a significant effect of

baseline levels of hunger ($F(1, 109) = 124.24, p < .01, \eta^2_p = .53$). There was no significant main effect of the mindfulness condition ($F(2, 109) = 1.17, p = .32$).

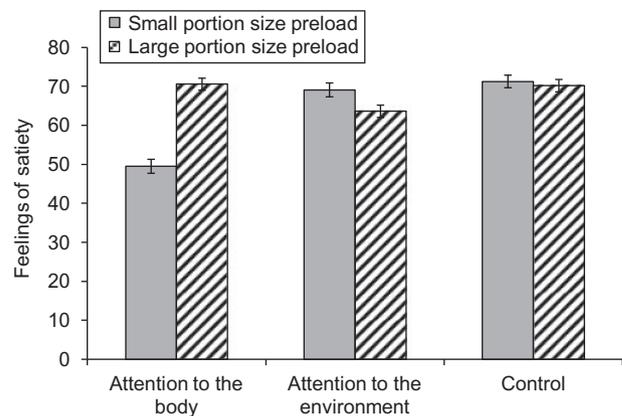
In line with our predictions, there was also a significant mindfulness by preload interaction ($F(2, 109) = 3.56, p < .05, \eta^2_p = .06$). To further examine this interaction effect, simple effect analyses were performed. These indicated that preload size significantly predicted satiety feelings in the mindful attention to body condition ($F(1, 109) = 19.40, p < .001, \eta^2_p = .15$) but not in the other two conditions (mindful attention to environment: $F(1, 109) = 0.40, p = .53$; control condition: $F(1, 109) = 1.72, p = .19$). More specifically, in the mindful to body condition, participants who had consumed a small preload felt less full ($M = 49.49$) than participants who had consumed a large preload ($M = 70.55, SD = 16.56$; see figure 3).

We also examined the simple effects of the mindfulness condition within each of the preload conditions. Findings revealed that after eating the small preload, participants in the mindfulness attention to the body condition felt less full ($M = 49.49$) than participants in the mindful attention to environment condition ($M = 69.08$) or control condition ($M = 71.24; F(2, 109) = 2.90, p = .06, \eta^2_p = .05$). In the large preload condition there was no significant effect of mindfulness ($F(2, 109) = 1.80, p = .17$).

Evaluation of the Preload. As expected, participants in the large preload condition perceived the preload as larger ($M = 5.36$) than participants in the small preload condition ($M = 3.28, F(1, 105) = 59.54, p < .001$). Also, participants in the large preload condition perceived the preload as sweeter ($M = 5.43$ vs. $M = 4.44; F(1, 105) = 19.21, p < .001$), more creamy ($M = 5.88$ vs. $M = 5.26; F(1, 105) = 10.95, p < .01$), and more tasty ($M = 5.48$ vs.

FIGURE 3

FEELINGS OF SATIETY AS A FUNCTION OF MINDFULNESS CONDITION AND PRELOAD SIZE



NOTE.—Error bars represent standard error of means.

$M = 4.86$; $F(1, 105) = 4.57$, $p < .05$) than participants in the small preload condition. Correcting for these ratings in our analyses did not change any of our main findings. Moreover, the mindfulness condition or interaction between mindfulness condition and preload did not affect any evaluation of the preload.

Effects of Body Mass Index, Restrained Eating, and Dieting Status on Satiety Feelings. In separate analyses it was tested whether controlling for restrained eating, body mass index (BMI), or dieting status affected our findings. None of these covariates had an effect on satiety feelings after consumption of the preload (all F 's < 1.95 , NS); nor did including these variables affect our findings.

Discussion

These findings show that mindful consumers are better able to sense the physiological consequences of how much they have eaten. As in study 2, only when participants direct mindful attention to their bodies do feelings of satiety respond to the amount they have previously eaten. For participants who direct mindful attention to the environment or for participants in the control condition, there are no differences in feelings of satiety after consuming either a small or a large preload. This shows that mindful attention does not have a general effect, but that it matters where attention is focused.

Because there is no absolute value of how full consumers 'should' feel after a specific consumption, we can only assess whether satiety feelings correspond to differences in the amount of calories consumed. Participants who direct mindful attention to their bodies indeed report differences in satiety feelings according to how much they have previously eaten, however, they specifically feel less full after having consumed a small preload. A similar finding was observed in study 2, where participants in the mindful attention to body condition compensated by eating more after having consumed a small preload, rather than eating less after a large preload. This raises the possibility that mindful attention to the body particularly enhances consumers' feelings of not being satiated, which could have adverse effects on consumers' body weight, an issue we address in study 5.

STUDY 4

The previous studies indicated that mindful attention makes consumers more aware of internal hunger and satiety cues and thereby improves compensation across consumption episodes. In the current study we examine a potential alternative explanation, namely that mindfulness enhances compensation through a more cognitive route where consumers pay more attention to how much they have eaten. To examine this, we assess whether mindful

consumers react differently to a cue that makes previous consumption more visually salient. Specifically, food waste such as chicken bones and pistachio shells can decrease consumption when these stay in sight rather than are removed from sight (Kennedy-Hagan et al. 2011; Wansink and Payne 2007). We test whether mindful attention affects reliance on a visual cue by serving participants similar amounts of pistachio nuts, with or without a visual cue of previous consumption (i.e., the shells of the nuts) and assessing subsequent food intake. We expect that after our mindfulness manipulation consumption is not affected by whether a visual cue of previous consumption is present because the physiological signals are similar. In contrast, if mindfulness enhances compensation by making consumers pay more attention to the amount of previous consumption, a visual cue that makes this amount more salient would further facilitate this process and decrease subsequent consumption.

Method

Participants and Design. Ninety-five students were randomly assigned to a 2 (Mindfulness condition: mindful attention to the body vs. control) \times 2 (Visual cue of consumption: present vs. absent) between-subjects design. Seven participants were excluded for not completely finishing the preload and three participants because they indicated not to have followed the mindfulness instructions (score of lower than four on a 7 point scale). This left 85 participants in the analysis (14 men, 71 women; mean age 20.8 years). They received a small monetary compensation.

Procedure and Measures. Participants were seated in individual cubicles and informed that they would participate in a series of unrelated studies. First, baseline feelings of hunger were assessed by two items on a 100 mm VAS scale ("How hungry do you feel at this moment?", "How full do you feel at this moment?" 1 = Not at all hungry respectively full, 100 = Very hungry respectively full; $\alpha = .80$). Participants also indicated whether they had breakfast and lunch or engaged in sports before the experiment. Then participants were asked to evaluate an audio fragment (cf. studies 2 and 3) that constituted the mindfulness manipulation.

Next, participants were served a bowl of 55 shelled pistachio nuts and asked to finish the plate of nuts completely, ostensibly because the researchers were interested in how consumers experience the shelling of nuts. Participants in the no visual cue condition were provided with a small bin with a lid and instructed to dispose of the shells in the bin. In the visual cue condition, participants were not provided with a bin and disposed of the pistachio shells on a plate. In line with the cover story, all participants filled out questions regarding the taste of the nuts

and the experience of shelling the nuts. In the no visual cue condition, the experimenter took away the bin after participants had eaten the nuts and before they proceeded. In the visual cue condition participants simply proceeded while the plate with pistachio shells remained on their table, until the next taste test. Participants filled out several neutral filler tasks on study evaluation. In between the filler tasks, participants were asked to give an estimation of the absolute number and grams of nuts they had previously consumed, and the number of calories. They also rated the preload in terms of amount of nuts (1 = Little, 7 = A lot) and caloric content (1 = Low caloric content, 7 = High caloric content).

Then, participants were served two bowls of savory snacks (one bowl of 30 g and one bowl of 40 g) of which they could consume as much as they like, in what was presented as a taste test. In the visual cue condition, at this moment the plate of pistachio shells was taken away by the experimenter. Participants were asked the same two questions about current hunger and satiety feelings as at the beginning of the experiment ($\alpha = 0.79$) and rated both snacks on saltiness, dryness, and palatability, and then they filled out another neutral filler task, to give them more opportunity to consume the snacks. Finally, they filled out demographics (age, gender, weight and height, dieting status), were probed for suspicion, and filled out the restrained eating subscale of the DEBQ (van Strien et al. 1986). After participants left, the bowls of savory snacks were weighed to assess amount of consumption.

Results

Baseline Levels of Hunger. Despite random assignment to conditions, baseline feelings of hunger marginally differed across conditions ($F(3, 81) = 2.12, p = .10$). Baseline levels of hunger were therefore controlled for in the reported analyses.

Estimation of Previous Consumption. A multivariate analysis of variance was carried out with the visual cue condition, the mindfulness condition, and the interaction between these as factors, baseline levels of hunger and gender as covariates, and the various estimates of previous consumption as dependent variables. Overall, participants underestimated the number of nuts consumed ($M = 37.4, SD = 12.44$, significantly below the actual number of 55 nuts: $t(84) = -13.07, p < .001$) and the number of calories consumed ($M = 251.05$ kcal, $SD = 242.39$, significantly below the actual amount of 429 kcal: $t(82) = -6.69, p < .001$).

Importantly, after the instructions to focus mindful attention on the body, participants did not estimate the (absolute) number of nuts differently ($F(1, 76) = 0.88, p = .35$); nor were they more accurate in estimating their previous consumption (absolute difference between estimated

number of nuts consumed and actual number of nuts) than participants in the control condition ($F(1, 76) = 0.30, p = .58$), or rated amount of consumption differently on the Likert scale ($F(1, 76) = 0.30, p = .59$). There was a marginally significant effect of mindfulness condition on how many calories participants estimated to have consumed in the pistachio preload ($F(1, 76) = 2.80, p = .10$), with participants in the mindful condition having lower estimations ($M = 203.66$) than participants in the control condition ($M = 298.46$), but when examining the absolute difference between the estimated and actual number of kilocalories, there was no significant difference between the two conditions ($F(1, 76) = 0.17$), and they also did not differ in their estimates of consumed calories on a Likert scale ($F(1, 76) = 0.09, p = .76$).

There were no other significant main effects on estimates of previous consumption (all F 's less than 2.17). For none of the dependent variables was the interaction between mindfulness and visual cue significant (all F 's less than 2.10). In general we thus find no evidence that mindfulness affects memory for consumption.

Subsequent Consumption. The visual cue condition, the mindfulness condition, and the interaction between these two were entered as independent variables in an ANOVA with amount of subsequent consumption as a dependent variable. Baseline levels of hunger and gender were included as covariates. No significant main effects of mindfulness ($F(1, 79) = 0.09, p = .77$), visual cue ($F(1, 79) = 0.25, p = .62$) or gender ($F(1, 79) = 0.45, p = .51$) were present. Baseline levels of hunger had an effect: the hungrier participants were at the outset of the study, the more snacks they ate later on ($F(1, 79) = 5.15, p < .05$). The interaction between the mindfulness condition and visual cue condition was marginally significant ($F(1, 79) = 2.91, p = .09$). Examining this further, none of the underlying simple effects reached significance. Tentatively looking at the pattern suggests that participants in the control condition tended to eat more when no visual cue of previous consumption had been available to them ($M = 28.27$ g) compared to when they had been reminded of their consumption by the pistachio shells ($M = 21.10$ g, $F(1, 79) = 2.52, p = .12$), even though the underlying effects were not significant. For participants in the mindfulness condition having a visual cue of previous consumption did not affect subsequent consumption ($F(1, 79) = 0.74, p = .40$; $M_{\text{visual cue}} = 23.39$; $M_{\text{no visual cue}} = 21.20$).

A similar analysis as described earlier was conducted with levels of hunger after consumption of the pistachio as a dependent variable. No effects of visual cue, mindfulness, or its interaction were found. This is in line with expectations because all participants ate the same number of pistachio nuts in this experiment.

Effects of BMI, Restrained Eating, and Dieting Status. In separate analyses we examined whether participants' BMI, restrained eating level, or dieting status affected our results. None of these covariates affected subsequent snack consumption (all F 's less than 2.10, NS); nor did inclusion of these covariates change the pattern of our reported findings.

Discussion

These findings indicate that after focusing mindful attention on the body, consumers do not remember their previous consumption more accurately or differently, rendering a cognitive route of compensation an unlikely explanation for our compensation findings in the previous studies.

STUDY 5

Our findings thus far show that mindfulness does not make consumers better at remembering previous consumption but facilitates the awareness of hunger and satiety cues. This raises the question whether chronic levels of mindfulness would also lead to more effective compensation in the long run, as evidenced by lower fluctuations in body weight. Additionally, given that increased consumption after a low caloric preload was more prominent in the previous studies than decreased consumption after a high caloric preload, the question is whether body weight itself is affected. In the current study 5 we therefore examine how trait mindfulness and experience in mindfulness practice are related to body weight and fluctuations in body weight. We use weight measurements collected with an Internet-connected scale over a period of 35 months, allowing us to study objective fluctuations in individuals' weight over a longer period of time in a sample of the general population.

Method

Participants and Design. For the current study we partly made use of secondary data supplemented with additional measurements, using the Longitudinal Internet Studies for the Social Sciences (LISS) panel administered by CentERdata (Tilburg University, The Netherlands). The LISS panel is a representative sample of 8000 Dutch individuals (of 5000 Dutch households) participating in monthly Internet surveys. The panel consists of a true probability sample of households drawn from the population register, with the help of the Dutch Central Bureau of Statistics. Participants receive €7.50 per half hour as financial compensation for participation. Households that do not have access to a computer and/or Internet are provided with a computer and/or Internet access. For more information on the LISS panel, see www.lissdata.nl and Scherpenzeel and Das (2010).

As part of a study in the panel, 1290 participants had been asked to weigh themselves (for details, see Kooreman and Scherpenzeel 2014). The minimum weighing frequency varied (once a day vs. once a week vs. unspecified) as well as the feedback that participants received (feedback of their weight vs. feedback of their weight with their own target weight vs. feedback of their weight with recommended norm range). In August 2012, we selected 514 participants from this study to participate in a survey on "everyday experiences." These participants had a minimum age of 18 years at the start of the weighing study, had shown compliance to requests for weight measurements in previous months, and had participated in a survey on eating styles in July 2010. In total, 467 participants completed the survey (response rate 90.9%). After excluding participants with measurement error in the weight data (3 participants), and those reporting pregnancy (13 participants), eating disorder (1 participant), or use of medication that affects weight (44 participants), there were 406 participants in the data set who continued to provide weight information up to January 2014. Upon inspecting the additional data up to January 2014, incidental measurement errors were found and removed for nine participants, for a further 19 participants. Part of the weighing data was not taken into account due to pregnancy, medical issues that arose during the weighing period (e.g., cancer treatment), or use or discontinued use of medication with effects on weight, and one participant was removed completely because medical issues remained through most of the weighing period. Thus 405 participants remained in the analysis. On average, participants provided weighing data for 28.5 months, with an average of 11.3 weighing measurements per month. Background variables of participants and how these compare to the Dutch population can be found in table 1.

TABLE 1

DEMOGRAPHICS OF STUDY 5 AS COMPARED TO THE DUTCH POPULATION

Demographics	Sample (%)	Dutch population ^a (%)
Male	52.6 %	49.5 %
Age (categorized in age groups)		
Younger than 20 years	0.2 %	23.5 %
20–39 years	14.3 %	25.0 %
40–64 years	56.0 %	35.9 %
65–79 years	26.9 %	11.6 %
80 years or older	2.5 %	4.0 %
Education		
Primary	7.7 %	8.4 %
High school (vocational)	23.5 %	23.0 %
High school (general)	8.4 %	10.8 %
Vocational	27.7 %	29.3 %
College	24.0 %	18.2 %
University	8.9 %	9.4 %

^aBased on demographics for 2011 provided by Statistics Netherlands (www.cbs.nl).

Procedure. To assess trait mindfulness, participants filled out the observing subscale of the KIMS (Baer et al. 2004; see also study 1) and the MAAS (Brown and Ryan 2003). Participants were then asked to what extent they had experience in mindfulness or meditation and rated the extent to which they had experienced pain in the previous four weeks. On the basis of the participant's panel identification number, participants' responses in the mindfulness questionnaire were matched to measures in the weighing project, subjective health measures, their scores on the DEBQ in a previous eating styles survey, and demographic variables.

Measures. The observing subscale of the KIMS (Baer et al. 2004) assessed trait mindfulness (see study 1). We were interested in whether we could differentiate in the effects of the foci of dispositional mindful attention on body weight, in a similar way as the foci of mindful attention had different effects in the studies on state mindfulness. The observing subscale includes six items that tap into the extent to which participants pay attention to their bodies (e.g., "I notice changes in my body, such as whether my breathing slows down or speeds up"), three items that tap into whether participants pay attention to aspects of their environment (e.g., "I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing"), and three items that assess the extent to which participants are aware of their feelings and emotions (e.g., "I notice when my moods begin to change"). Confirmatory factor analyses assessed whether the items of the observing subscale tap into one construct "Observing," as formulated in the original research, or whether three different factors can be distinguished; "Attention to body," "Attention to environment," and "Attention to feelings and emotions," based on the face validity of the items as described earlier. The analyses showed that the three factor model ($\chi^2(51) = 295.03$, $p < .001$, root mean square error of approximation [RMSEA] = 0.11, comparative fit index [CFI] = .91) outperformed the one construct model ($\chi^2(54) = 511.5$, $p < .001$, RMSEA = 0.15, CFI = .83; comparison test: $\Delta\chi^2(3) = 216.47$, $p < .001$). We therefore used the three different constructs in our analyses (attention to body, $\alpha = .87$; attention to environment, $\alpha = .79$; attention to feelings, $\alpha = .84$).

Experience in mindfulness/meditation was assessed by asking, "To what extent do you have experience in mindfulness and/or meditation?" (1 = No experience at all, 7 = A lot of experience). As in study 1, many participants (76.0 %) reported no or little experience with mindfulness (1 or 2 on the scale), but given the larger sample size we investigated and report on the association between experience in mindfulness and BMI/variance in weight.

The DEBQ (van Strien et al. 1986) was administered to assess restrained eating (e.g., "How often do you try not to eat over the course of an evening, because you are

dieting?", 10 items, $\alpha = .91$, see also study 1), emotional eating (e.g., "If you feel dejected or discouraged, does that make you feel like eating something?", 13 items, $\alpha = .96$), and external eating (e.g., "If you pass by a bakery, does that make you feel like buying something yummy?", 10 items, $\alpha = .83$) (van Strien et al. 1986).

During the period of weighing, participants were asked to answer several questions about their health each month. They indicated whether there were any circumstances that could have affected their weight (e.g., pregnancy, medicine use) and how they would characterize their health ("How would you describe your health in general?" 1 = Poor, 5 = Excellent). For each participant, this last item was averaged over the study period across all reported months as a measure of subjective health (for the month of September 2012, this information was missing). Age at the start of the weighing period was measured as a continuous variable.

Weight was registered using Internet-connected weighing scales that participants had received for the weighing project. Participants logged in on the weighing scale, and their measures of weight were automatically saved with their unique identification number. Thus participants did not self-report their weight. BMI of participants was calculated using the weight as measured by the scale and height as reported by participants. BMI was calculated for participants for each weighing moment, and means of these measures were calculated over the course of the 35 months. We also computed scores for the number of times participants weighed themselves each month and the number of months they participated in the study.

To examine weight fluctuation, the SD of the weight measures was calculated for each participant to obtain a continuous measure of intrapersonal weight variability (cf. Blair et al. 1993; Kooreman and Scherpenzeel 2014; Lissner et al. 1991). In the analyses we controlled for average BMI during the weighing period because individuals with a higher BMI tend to fluctuate more than individuals with a lower BMI.

Results

Effects on BMI. Zero-order correlations between KIMS subscales and mean BMI showed a nonsignificant correlation for attention to the body and BMI ($r = -.06$, $p = .26$) and marginally significant negative correlations between the other two subscales and BMI (attention to environment: $r = -.09$, $p = .06$; attention to feelings: $r = .08$, $p = .10$). Results of the regression analysis (overall model $R^2 = .20$) revealed that mindful attention to the body did not predict BMI ($t(378) = -1.07$, $p = .29$); nor did mindful attention to environment or mindful attention to feelings (see table 2 for predictor and control variables and results). Collinearity statistics for none of the explanatory variables in the model surpassed critical levels (all variance inflation factors less than 2.4).

TABLE 2

RESULTS OF REGRESSION ANALYSES PREDICTING MEAN BMI AND WEIGHT FLUCTUATIONS OVER A PERIOD OF 35 MONTHS

Predictor variable	Outcome variable: mean BMI across 35 months ($n = 394$) ^a				Outcome variable: Weight fluctuations (standard deviation in weight measures) across 35 months ($n = 394$) ^a			
	B	β	t	p	B	β	t	p
Mindful attention to body (KIMS)	-0.21	-0.07	-1.07	.29	-0.16	-0.18	-2.64	<.01
Mindful attention to environment (KIMS)	-0.01	-0.00	-0.07	.95	0.07	0.08	1.23	.22
Mindful attention to feelings (KIMS)	-0.10	-0.04	-0.49	.62	0.04	0.05	0.66	.51
Age	0.00	0.01	0.21	.84	-0.02	-0.23	-4.13	<.01
Gender (0 = male, 1 = female)	-1.32	-0.18	-3.57	<.01	-0.22	-0.10	-1.97	.05
Subjective health	-1.13	-0.19	-3.85	<.01	-0.16	-0.09	-1.79	.08
Restrained eating (DEBQ)	1.19	0.25	4.88	<.01	0.00	0.00	0.02	.98
External eating (DEBQ)	0.01	0.00	0.03	.98	0.04	0.02	0.34	.73
Emotional eating (DEBQ)	0.41	0.08	1.34	.18	-0.00	-0.00	-0.04	.97
Education level	-0.40	-0.17	-3.28	<.01	0.01	0.01	0.28	.78
No. of months weighed	-0.08	-0.14	-2.74	.01	0.00	0.02	0.29	.77
Average no. of monthly weight measures	0.04	0.09	1.90	.06	0.01	0.10	2.03	.04
Feedback target weight (compared to control feedback)	-0.70	-0.09	-1.74	.08	0.02	0.01	0.12	.90
Feedback norm weight (compared to control feedback)	0.24	0.03	0.57	.57	0.27	0.12	2.21	.03
Mean BMI					0.09	0.29	5.56	<.01

BMI, body mass index; DEBQ, Dutch Eating Behavior Questionnaire; KIMS, Kentucky Inventory of Mindfulness Scale.

^aParticipants with missing values on any of the variables were removed from the analysis.

Effects on Weight Fluctuations. Weight fluctuation over 35 months (SD) was the variable of interest. Zero-order correlations showed that mindful attention to the body was negatively correlated to weight fluctuation ($r = -.12, p = .02$). Mindful attention to environment ($r = -.07, p = .16$) and mindful attention to feelings ($r = -.05, p = .35$) were not correlated to weight fluctuation. Table 2 provides the results of the regression analysis (overall model $R^2 = .19$). Mindful attention to the body had a significant negative relationship with weight fluctuation ($\beta = -0.18, t(377) = -2.64, p < .01$), such that individuals who indicated to paid attention to body sensations varied less in their weight. Other subscales of mindfulness were not related to fluctuations in weight.

In a detailed inspection of the data, we identified one potential influential case. This data point did not appear to arise from measurement or entry errors but appeared to be a legitimate case, resulting from natural variability. When excluding this specific case, the correlation between mindful attention to the body and weight fluctuation would remain significant, but the regression coefficient would not reach significance with the current set of control variables ($p = .11$). Subsequent detailed inspection of the case showed that the person had relatively high fluctuation in weight, showing a pattern of gradual weight loss and weight gain over time, not unlike several other participants albeit to a larger extent. Taking everything into account, we conclude that a relationship between mindful attention to the body and weight fluctuation appears present, but that more research is needed to further substantiate this conclusion, which we elaborate on in the discussion section.

Experience in Mindfulness. We also assessed how experience in mindfulness/meditation was related to the weight measures. These results should be interpreted with care because this may be related to lifestyle differences between people: people who attend mindfulness training may differ from people who do not attend such training in multiple ways. Experience in mindfulness was positively correlated to all three subscales of mindfulness ($p < .01$), negatively to BMI ($r = -.10, p = .05$) and not related to weight fluctuation ($r = -.06, p = .25$). A regression analysis with BMI as a dependent variable, experience in mindfulness as an independent variable, and similar control variables as reported in table 2 showed a significant and negative relationship between experience in mindfulness/meditation and BMI ($\beta = -0.12, t(380) = -2.45, p < .05$). Participants with more experience in mindfulness had a lower BMI. A regression analysis for weight fluctuation showed no significant effect of experience in mindfulness ($t(379) = -0.66, p = .51$).

Discussion

The findings of study 5 provide additional support that paying mindful attention to the body is related to positive weight outcomes. Relying on objective weight measures, we find that individuals who direct more mindful attention to their bodies vary less in their body weight over a period of three years. This finding is in line with our argumentation that paying mindful attention to the body helps consumers to compensate for previous intake and maintain an overall constant food intake, and extending this logic, keep a constant body weight. These results further underline that

it matters where mindful attention is directed: mindful attention to the environment and to feelings had no effect on weight fluctuation. Given the influential case in our data, results should be interpreted with care, and future research should test the robustness of this effect.

GENERAL DISCUSSION

Over the last decades, a wealth of research has convincingly shown that cues in the environment have the capacity of mindlessly driving our food consumption (Wansink 2010). This has led scholars to label our eating environment as obesogenic and our eating behavior as mindless. The current research has examined the opposite side of the coin, by examining *mindful* eating and, more broadly speaking, by looking at factors that improve rather than undermine healthy eating patterns. Our findings show that mindfulness leads consumers to be more aware of physiological cues and adjust further food consumption accordingly. We have examined the effects of both chronic mindfulness and short mindfulness meditations and shown that both can enhance consumers' compensation for previous food intake. Moreover, whereas previous studies have identified a focused attention as a defining element of mindfulness, they have been largely silent on whether it mattered where this attention was focused. Our findings show that the focus of mindful attention is crucial to the effects it has; a mindful meditation that focuses attention on the body enhances consumers' awareness of hunger and satiety cues and increases compensation for previous food intake, but mindfulness meditation with a different focus of attention does not. Also for chronic mindfulness, specifically mindful attention to the body is related to a more stable body weight, suggesting that also in the long run particularly mindful attention to the body, rather than a general mindfulness effect, provides consumers with important health benefits related to food consumption.

Up until now, the concept of mindfulness has mostly been applied in clinical contexts to improve psychological well-being (Brown et al. 2007). Mindfulness-based interventions in the context of eating have focused on individuals trying to lose weight and aim at changing individuals' maladaptive thoughts toward food (Alberts et al. 2010; May et al. 2010; for a recent exception, see Marchiori and Papiés 2014). The current study shows that also among a nonclinical population, mindfulness to the body is a relevant predictor of an individual's fluctuation in body weight. Moreover, mindfulness appears to be a unique trait related to compensation in food consumption, predicting compensation over and above other personality traits such as self-control, self-awareness, and restrained eating. Overall, our findings illustrate mindfulness' applicability to food consumption for consumers in general, demonstrating that even a very short manipulation of mindful

attention to the body can alter responsiveness to physiological cues.

We have argued that paying mindful attention to the body enables individuals to attend more closely to physiological cues of hunger and satiety, and that this drives their later compensation behavior. An alternative hypothesis is that through enhanced attention more generally, mindful individuals can better register how much they eat. However, if mindfulness would lead individuals to better encode how much they eat, we would expect that both mindfulness conditions, rather than only the mindful attention to the body condition, would show enhanced compensation. When testing this alternative explanation more directly in study 4, we find that an individual's recall of the amount of previous consumption is not affected by the mindfulness training, indicating that consumption amount is not encoded or remembered differently.

Our finding that only paying mindful attention to the body, but not mindful attention to the environment, leads to enhanced compensation also lends support to the idea that an improved access to hunger and satiety cues is the driving mechanism. A direct test of this hypothesis (experiment 3) indeed shows that paying mindful attention to the body leads individuals to become more aware of the hunger and satiety cues that develop after preloads of different caloric contents. One limitation is that the effects of mindfulness on the awareness of hunger and satiety cues and on compensation behavior are necessarily studied in separate studies, and we can therefore not draw a direct causal pathway. We speculate that the access to these hunger and satiety cues can occur at different levels of consciousness. Study 3 shows that participants' enhanced access to hunger and satiety cues after a mindfulness manipulation can come into full consciousness and be reported on when participants are specifically asked about this. In study 1 and 2, where hunger and satiety cues were only briefly asked about, similar effects were found on compensation behavior but not on hunger and satiety reports, presumably because more extensive measures are needed for these to come into full consciousness.

The distinction we make between different foci of attention has implications for both the food consumption and mindfulness literature. Whereas several studies on food consumption have demonstrated that a lack of attention undermines compensation behavior (Bellissimo et al. 2007; Higgs and Woodward 2009; Mittal et al. 2011), our findings suggest that to improve responsiveness to hunger and satiety cues, it is not enough to enhance attention in general, but this attention should be directed to (internal sensations of) the body. This is further supported by the finding that being chronically more mindful of the body's sensations is related to less fluctuation in weight across longer periods of time, whereas a higher dispositional mindfulness with different foci is unrelated to fluctuation in weight. It should be noted that our mindful attention meditation does

not direct individuals' attention directly to their stomach; nor are hunger and satiety cues explicitly mentioned. It appears that focusing on feeling different parts of the body and experiencing sensations such as breathing makes a whole system of body sensations more accessible. This is in line with recent findings that the awareness of different body sensations, such as heartbeat, breathing, and feelings of satiety, are related (Herbert et al. 2012). Distinguishing between different foci of attention in mindfulness and its effects in different applications could shed more light on the mechanisms underlying mindfulness.

Our findings on the different effects of foci of attention on mindfulness are also interesting in light of how trait mindfulness should be measured. Among mindfulness scholars there is discussion as to whether trait mindfulness should be considered as a single construct (e.g., MAAS) or whether mindfulness encompasses a range of specific skills (e.g., KIMS; Baer et al. 2006; Bishop et al. 2004; Grossman 2011). In several of our studies we have collected data for both the MAAS and the KIMS, and we found that the two scales do not converge and are related to different outcomes. Specifically, in study 1 the MAAS and KIMS observing subscale were not significantly correlated, and when examining this in study 5 (not reported in the results section of this study) we found a negative correlation ($r = -.12$).

In study 5 there was furthermore a marginal positive relationship between the MAAS and BMI. Even though our experimental findings indicate that particularly mindful attention to the body rather than mindful attention directed elsewhere facilitates compensation, we did not expect an inverse relationship with BMI. Also, a negative relationship was present between MAAS and experience in mindfulness. This raises concerns about the validity of the scale, as experience in mindfulness and meditation provides a clear external referent to define mindfulness. Although some prior studies have found meditation experience to be positively related to MAAS scores (Brown and Ryan 2003), several studies have failed to find such associations (e.g., Baer et al. 2006; MacKillop and Anderson 2007). The MAAS has been criticized for measuring the absence of mindlessness rather than mindfulness (Grossman 2011). Possibly the MAAS measures enhanced attention more generally and is not able to tap into the more specific process of enhanced attention to the body that is related to positive weight outcomes. To gain a clearer picture of what qualities various measures of mindfulness tap into and how they relate to each other, future studies should investigate how general dispositional mindfulness and more specific elements of mindfulness relate to each other, as well as to eating behavior.

Relying on internal physiological cues in food consumption entails eating when hungry and stopping to eat when satiated. In two of our studies we found that mindful participants particularly felt less full after a small preload and

compensated by eating more. This raises the concern whether paying attention to the body is beneficial for consumers or could instead make consumers particularly sensitive to feelings of hunger. Even though being able to notice feelings of hunger is an important determinant of effective energy regulation (Herman and Polivy 1980; Johnson and Birch 1994), there is a possibility that an exaggerated attention to feelings of hunger could lead to overeating in the short term. However, we find that experience in mindfulness/meditation is related to a lower body weight (study 5). Even though this result is cross sectional and does not allow for causal inferences, together with our experimental findings this suggests that paying mindful attention to the body is an effective strategy to maintain a healthy and stable body weight in the long term.

One explanation for the finding that mindfulness leads people to feel less full after a small preload is that hunger feelings are easier to detect than satiety feelings, due to the evolutionary advantage of attending to a shortage of energy (Zheng et al. 2009). This may explain differences in short- and long-term effects of mindfulness. When novices learn to attend to body feelings, as was the case in our experiments, hunger feelings may predominate, whereas in the somewhat longer run people learn to respond to satiety feelings as well. In future research, it would be interesting to explore whether novices and experts indeed react differently to mindful attention to body exercises. Also, it would be relevant to explore whether focusing either on hunger or satiety has different effects on overall balancing of food intake, especially since ignoring hunger cues can interfere with effective energy regulation (Herman and Polivy 1980). In line with this, several studies have underlined the importance of giving children autonomy over how much they wish to eat because children who are restricted in their food intake by their mothers are less effective in self-regulating energy intake (Johnson and Birch 1994). In clinical practices where people are taught to rely on and detect physiological cues in food consumption, emphasizing eating when hungry is preferred over emphasizing stopping to eat when full because the latter has been experienced as restrictive (Ciampolini et al. 2013), and focusing on fullness specifically has also been found to be ineffective (Poothullil 2002).

In the current research we have focused on how mindful attention to the body facilitates compensation for previous amount of consumption or number of calories. In future research it would be interesting to also examine how mindful attention influences what consumers choose to eat and whether mechanisms are similar for more healthy or unhealthy foods. A recent study by Jordan et al. (2014) showed that mindfulness is related to healthier snack choices and can lead to more favorable attitudes toward healthy foods. It would be interesting to further explore how awareness of body sensations is related not only to amount of consumption but also food choice. Another

direction for future research could be to further explore the findings in study 4, where the pattern of results suggests that the presence or absence of a visual consumption cue may have less effect when consumers are mindful of their body. A more thorough investigation could extend our results to include a condition in which consumers are mindful of the environment. Mindfulness of the environment may make visual consumption cues more salient and could potentially increase their effect, as future research can investigate. We also want to urge future research to investigate longitudinal fluctuations in weight, across long time periods and for a larger sample. Our study 5 is a first investigation in this area, partly based on data collected for other purposes. Given the influential case in our data, more studies examining weight fluctuation patterns and individual differences are needed to further enhance our understanding of changes in weight over time and the extent to which these are related to mindful attention to the body.

Related to the question of whether focusing on hunger is beneficial to consumers is the question of whether the awareness of body sensations in general is always adaptive. An elevated level of body awareness might also be related to anxiety and exaggeration of bodily symptoms. A crucial distinction to be made here is between the awareness of body sensations and the accuracy of perception (Ceunen, van Diest, and Vlaeyen 2013). Mindful attention has not only been related to the awareness of body sensations but also specifically to accuracy of sensing body sensations, as assessed by measures in touch and breathing. Furthermore, trait mindfulness is negatively related both to the number of physical symptoms that individuals report and to health care utilization (Brown and Ryan 2003).

The distinction between paying attention to body sensations that leads to anxiety or exaggeration of body symptoms, on the one hand, and paying attention in order to perceive subtle body sensations accurately, on the other hand, also illustrates how mindfulness differs from attention more generally. How the body is attended to, particularly whether observation of body sensations is evaluative or not, is a critical determinant of the effects it has (Mirams et al. 2013). Mindfulness trainings practice guiding and sustaining attention on present-moment stimuli. Maintaining such focus inhibits further elaboration and leads to nonevaluative observation (Petter et al. 2013). In support of this, the ability to sustain mindful attention to breathing has been related to less rumination and depressive symptoms (Burg and Michalak 2011), whereas attention to external body appearance via a mirror decreases people's ability to compensate for prior food intake (van de Veer, van Herpen, and van Trijp 2015).

Amid an abundance of insights into factors that undermine consumers' eating behaviors and lead to mindless eating, the current study provides consumers with a positive perspective showing how they can improve their eating patterns. Rather than simply advising consumers to rely

on hunger and satiety cues, which is something people often struggle with, our findings give consumers more guidance on how responsiveness to hunger and satiety cues can be achieved. Simply focusing on several general and more accessible aspects of the body, such as breathing and posture, can improve a consumer's eating patterns.

DATA COLLECTION INFORMATION

The first author supervised the data collection of study 1 by research assistants at Wageningen University in the winter of 2013–14. The first and second authors jointly analyzed the data of this study. The second author supervised the data collection of study 2 by research assistants at Wageningen University in the fall/winter of 2010. The first and second authors jointly analyzed these data. For study 3, the first author supervised the data collection by research assistants at Wageningen University in the fall/winter of 2011. The first and second authors jointly analyzed these data. The first author supervised the collection of data for study 4 by research assistants at Wageningen University in the spring of 2012. The first and second authors jointly analyzed these data. For study 5, data were collected by CentERdata among the Longitudinal Internet Studies for the Social Sciences panel in the period between 2010 and 2014, as described in the method section of study 5. The first and second authors jointly analyzed these data.

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