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Key words: Mindfulness; Hedonic reactions; Hunger; Food cue exposure; Food intake.

Abbreviations: MAI = Mindful attention induction; FCE = Food cue exposure

Highlights:

- Mindful attention can attenuate tendencies to eat in response to hedonic properties of food
- Effects of attention with and without a mindful attitude were compared
- Subjective reactions to the hedonic properties of energy-dense foods and food intake were examined
- Following attention with a mindful attitude fullness increased and hunger did not whereas without a mindful attitude hunger increased and fullness did not
- Significantly fewer cookies were eaten ten minutes post-exposure following the mindful attention induction.

Title page

Attention with a mindful attitude attenuates subjective appetitive reactions and food intake following food-cue exposure

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Abstract:

Background: Excessive energy intake that contributes to overweight and obesity is arguably driven by pleasure associated with the rewarding properties of energy-dense palatable foods. It is important to address influences of external food cues in food-abundant societies where people make over 200 food related decisions each day. This study experimentally examines protective effects of a mindful attention induction on appetitive measures, state craving and food intake following exposure to energy-dense foods.

Method: Forty females were randomly allocated to a standard food-cue exposure condition in which attention is brought to the hedonic properties of food or food-cue exposure following a mindful attention induction. Appetitive reactions were measured pre, post and ten minutes after post-cue exposure, after which a plate of cookies was used as a surreptitious means of measuring food intake.

Results: Self-reported hunger remained unchanged and fullness significantly increased for the mindful attention group post-cue exposure whereas hunger significantly increased for the standard attention group and fullness remained unchanged. There was no significant between-group difference in state craving post-cue exposure and ten minutes later. Significantly more cookies were eaten by the standard attention group ten minutes post-cue exposure although no significant between-group differences in appetitive and craving measures were reported at that time.

Conclusion:

Our results point to a promising brief intervention strategy and highlights the importance of distinguishing mindful attention from attention. Results also demonstrate that mindful attention can influence food intake even when craving and hunger are experienced.

Key words: Mindfulness; Hedonic reactions; Hunger; Food cue exposure; Food intake.

Introduction

At present one in four adults can be described as obese and it is predicted that, if current trends continue, nine in ten adults will be overweight or obese by 2050 (Department of Health, 2013). The causes of obesity reflect complex interactions between genetic, behavioural, environmental and psychosocial factors (Butland et al., 2007; Jebb, 1997). In food-abundant environments where people make an estimated 200 food related decisions each day research indicates that eating predominately occurs to prevent hunger (Lowe, Van Steenburgh, Ochner, & Coletta, 2009; Wansink & Sobal, 2007). That is, eating happens before significant energy depletion and associated physiologic signals that form part of the homeostatic system are experienced (Lowe et al., 2009). It is recognised that much of this excessive energy intake that contributes to overweight and obesity, is driven by pleasure or the rewarding properties of readily available energy-dense palatable foods (Appelhans, 2009). Food consumption, in the absence of physical signals or energy deficit, is driven by hedonic hunger and reactions to hedonic properties of foods (e.g. sight, smell) rather than homeostatic mechanisms (Lowe & Butryn, 2007). Hedonic hunger, the motivation to consume food for pleasure, is often associated with increased susceptibility to enviromental food cues presenting a barrier to behaviour change and weight management (Lowe & Butryn, 2007; O'Neil, Theim, Boeka, Johnson, & Miller-Kovach, 2012). In experimental settings this is demonstrated by evidence that exposure to high-calorie food-cues increases appetitive responses such as hunger and desire to eat cued and non-cued foods (Ferriday & Brunstrom,

2008, 2010; Jansen, Nederkoorn, Van Baak, Kierse, & Guerrieri, 2009). The food-cue exposure paradigm, a reliable method for examining the effect of exposure to food, has also been shown to effect subsequent food intake of similar or identical cued foods (e.g., Jansen et al., 2009; Ferriday & Brunstrom, 2010).

Characteristics of the individual (e.g. emotional needs; Evers, Stok, & de Ridder, 2010), food or the food environment may exert influences that individuals may not wholly be aware of (e.g. Herman & Polivy, 2005; Marchiori & Papies, 2014). Unrecognised somatic and mental phenomena can trigger automatic reward-motivated behaviours, including eating (Caldwell, Baime, & Wolever, 2012). The role of automatic habitual tendencies associated with hedonic hunger are an obstacle to dietary educational approaches (Rothman, Sheeran, & Wood, 2009). Alternative and complementary approaches are required to understand and address automatic reward motivated behaviours associated with excessive food intake. In this respect the concept of mindfulness has received considerable attention (Mantzios & Wilson, 2015). Mindfulness, as defined by Kabat-Zinn (2003) encompasses receptive attention to whatever arises in the present moment with an open, curious non-judgmental attitude. Compared to normal functioning a mindful state is one of enhanced receptive awareness and attention to present reality (Brown & Ryan, 2003). Mindfulness techniques have been shown to moderate eating behaviours influenced at a perceptual or preconscious level (Kahn & Wansink, 2004; Wansink, 2010).

Mindfulness training interventions have been shown to increase discrimination between externally cued hunger and hunger associated with emotions (Baer, Fischer, & Huss, 2006), and to attenuate hedonic hunger reducing automatic relations between cravings and food intake (Alberts, Mulkens, Smeet, & Thewissen, 2010). Increasing awareness and attention to internal cues and cued responses can serve a "de-automatisation" function (Bargh, 1997; Baumeister, Heatherton, & Tice, 1994; Lattimore & Maxwell, 2004), improve health outcomes, enable weight regulation (Dalen et al., 2010), and facilitate successful self-regulation (Papies, Barsalou, & Custers, 2012).

In experimental settings mindfulness techniques that increase attention with a mindful attitude (e.g. non-reactive, non-judgemental) can influence both psychological and behavioural outcomes (e.g. Arch & Craske, 2006; Erisman & Roemer, 2010; Verplanken & Fisher, 2013). Specifically, the ability to mindfully observe thoughts and emotions has been shown to reduce craving (Lacaille et al., 2014), chocolate consumption (Jenkins & Tapper, 2014) and approach responses to appetitive foods (Papies et al., 2012). Under everyday living conditions the use of a brief mindfulness exercise (see Papies et al., 2012) changed participants' levels of hunger so it no longer influenced the attractiveness of unhealthy foods and eating choices (Papies, Pronk, Keesman, & Barsalou, 2014). In addition to these mindfulness inductions, the effects of mindfulness practices that are part of standard mindfulness-based intervention programmes have been investigated. For instance, following a guided 'body scan meditation' (14 minutes), one of the first exercises taught in

Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982), has been shown to make the translation of hunger into unhealthy snacking behaviour less likely compared to listening to an audiobook (Marchiori & Papies, 2014). However, the body-scan does not directly relate to or address automatic eating nor does it encourage a mindful attitude to thoughts and emotions around eating (Mantzios & Wilson, 2015).

Although research indicates that mindfulness techniques show promise in altering habitual or automatic eating behaviour there is considerable variation in the content and structure of techniques used (e.g. Alberts et al., 2010; Forman et al., 2007; Jenkins & Tapper, 2014; Moffitt, Brinkworth, Noakes, & Mohr, 2012). As a consequence caution is required when interpreting these findings and attributing beneficial effects to mindfulness per se, or to common practices in mindfulness-based interventions (Grossman & Van Dam, 2011). The main aim of the current study was to test the influence of mindful attention on eating behaviour. The "mindful attention induction" (MAI) was developed based on a systematic review of existing inductions and incorporates key elements of mindful breath awareness practice (Malinowski, 2013) that is a core technique of multicomponent MBSR programmes (Brown, Ryan, & Cresswell, 2007; Kabat-Zinn, 1990). The objective of the mindful breath awareness practice is to foster a state of present moment awareness involving a non-reactive and non-judgemental attitude. The development of the MAI was motivated by a need to qualify the use of mindfulness within research, clearly stating how it has been operationalised or manipulated each context (Davidson, 2010). In doing so this study begins to address the considerable variation in the use of mindfulness techniques in eating related research. By combining our MAI approach with an established food-cue exposure methodology this study examines how brief mindful attention practice may alter habitual or automatic reactivity to food cues that typically leads to overeating.

In the current study participants were randomly allocated to either an attention (control) or brief mindfulness attention induction (MAI). This was followed by a standard food-cue exposure task (Jansen et al., 2009) and thus participants were either subjected to a standard food-cue exposure (Standard-FCE) or to a food-cue exposure following a mindful attention induction (Mindful-FCE). The Mindful-FCE fostered a decentred non-reactive observational stance to phenomena, thus inviting attention with a mindful attitude. By contrast, the Standard-FCE brought attention to food properties without prior guidance on the processing of cues or the automatic quality of reactions to cues, thus representing attention without a mindful attitude. Based on evidence suggesting that mindful attention can influence both psychological and behavioural outcomes we expected that compared to the Standard-FCE participants Mindful-FCE participants would experience lower increases in hunger, feeling like eating, desire to eat and craving, but an increase in fullness immediately post food-cue-exposure. These effects were expected to be short-lived therefore appetitive measures were repeated 10 minute post-cue exposure, directly before measuring food intake. It was predicted that Standard-FCE would result in greater food intake compared to Mindful-FCE. Aspects of state mindfulness were measured to see if they would be influenced by the MAI. Liking and desire to eat the cued foods, mood and awareness of the experimental hypotheses were measured to examine alternative influences on measures of appetite and food intake.

Methods

Design

A mixed factorial design was employed. Experience of Standard-FCE or Mindful-FCE served as the between subjects factor and time of assessment the within subjects factor (pre-exposure vs. post-exposure vs. end-of-delay). Outcomes were assessed using visual analogue scales for hunger, fullness, feeling like eating and desire to eat, and self-report Likert scales for craving. Food intake was measured as number of items consumed. After participants had completed the pre-exposure assessments the experimenter (NF) opened an envelope for each participant containing their group assignment. These envelopes had been prepared using a random allocation algorithm by a third party blind to the nature of conditions. Participants had an equal chance of assignment to either condition. (See Figure 1 for a visual presentation of the experimental design).

Participants

Females (18-50yrs) from a university research participants panel, and university staff, were invited to take part in a "Food and Attention" study. Ethical approval was obtained from the University's Research Ethics Committee. A brief screening telephone interview ensured participants met inclusion criteria: 1) regularly eating between meals and 2) liking crisps and chocolate. Exclusion criteria were 1) Body Mass Index (BMI) < 18.5 or > 39.5; 2) currently pregnant; 3) presence of food allergy; 4) diabetes diagnosis; 5) having sought medical help in past six months for eating disorder and/or mental health problems; 6) current use of anti-depressant and/or weight-loss medication; 7) any previous formal or informal meditation experience (including yoga and self-help books or audio recordings); and 8) actively trying to reduce weight (independently or on weight loss programme). Eighty-seven women expressed an interest in taking part. Of the sixty-three eligible participants invited to take part forty-one

(*M*/*SD*: Age 30yrs, ± 7.7; BMI 25.4kg/m^2 ± 0.7) completed the online survey and the subsequent experiment. Of the 24 participants who did not meet eligibility criteria six were actively trying to lose weight, five had a BMI > 39.5, five were on anti-depressant and/or weight-loss medication, four had previous experience of mindfulness training, two were unable to attend, one was pregnant and another had a diabetes diagnosis. All of the forty-one participants reported liking and eating chocolate and crisps, and 72.5 % ate between meals almost every day. Data from one participant were excluded from analyses as she indicated that due to personal circumstances she had been unable to provide reliable responses, leaving a total of 40 participants (20 in each group).

Measures

Pre-exposure control measures. Dispositional Mindfulness was assessed with the 39-item Five-Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) using a five-point Likert scale ranging from "*Never or very rarely true*" to "*Very often or always true*". The current study reports the total score as an overall measure of dispositional mindfulness with higher scores indicating greater dispositional mindfulness (Baer, Smith, et al., 2006). Internal consistency was satisfactory for the total score (α = 0.88). Eating attitudes relating to hedonic eating behaviour were assessed with the 18-item Three Factor Eating Questionnaire (TFEQ-R18V2) with subscales measuring uncontrolled eating (UE), emotional eating (EE), and cognitive restraint (CR; Cappelleri et al., 2009). The four-point Likert scale ranged from "*Definitely true*" to "*Definitely false*" with responses transformed to a 0-100 scale in line with common practice for the TFEQ. Higher scores indicate greater uncontrolled and emotional eating and greater cognitive restraint. Internal consistency was satisfactory for UE, EE and CR (α = 0.83, 0.93, 0.74 respectively). The FFMQ, TFEQ, age and BMI recorded by self-report and anthropomorphic measures were included to ensure groups did not differ in these characteristics.

178 *Appetitive ratings & Food intake*. Four Visual Analogue Scales (VAS) were used to
179 assess hunger, fullness, feeling like eating and desire to eat pre-, post-exposure and ten
180 minutes after post-exposure (end-of –delay). Each VAS were preceded by the phrase "*Right*
181 *now, I feel…*" followed by a 0-100mm line used to indicate the responses: hungry (not at all
182 /very hungry), full (not at all /very full), feel like eating (not at all/very much), and desire to
183 eat food (absolutely no desire/very strong). Participants could not refer to previous appetitive
184 VAS ratings. Seven additional VAS, assessing aspects of sociability and self-pride, were
185 included to reduce the likelihood that participants would guess the experimental hypotheses.
186 VAS scales in appetitive research have shown good test-retest reliability and sensitivity to
187 subtle changes in appetite (Stubbs et al., 2000). Twelve Maryland chocolate chip cookies
188 were presented as a surreptitious ad libitum eating opportunity 10 minutes after post-cue
189 exposure. The number of cookies consumed served as a measure of food intake.

190 *State craving*. State craving was measured using the 15 item state Food Cravings
191 Questionnaire (Nijs, Franken, & Muris, 2007). The FCQ provides a total score and five
192 subscales: 1) An intense desire to eat; 2) Anticipation of relief from negative states and
193 feelings as a result of eating; 3) Craving as a physiological state; 4) Obsessive preoccupation
194 with food or lack of control over eating; 5) Anticipation of positive reinforcement that may
195 result from eating. A five-point Likert scale was used that ranged from "*Strongly Agree"* to
196 "*Strongly Disagree"*. Higher scores indicate greater state craving. The total and subscales had
197 good internal consistency with Cronbach coefficients ranging between α =0.77 and 0.97.

198 *Liking or desire for cued food and current mood*. VAS (0-100mm line) were also
199 administered to assess reactions to cued foods in terms of liking (not at all/really like this
200 food) and desire to eat the food (absolutely no desire/a very strong desire to eat this food).
201 Current mood was assessed using VAS in terms of happiness (not at all/very happy) and

relaxation (not at all/ very relaxed). These measures were included in order to rule out alternative explanations for any between group differences.

State mindfulness. Aspects of state mindfulness were measured using five VAS items adapted from validated mindfulness scales. Items (M1-M5) measured the extent to which participants noticed internal and external phenomena: M1) "*I feel myself getting carried away by my thoughts rather than just noticing them*"; M2) "*I pay attention to my thoughts and feelings*"; M3) "*I am aware of my thoughts, feelings and bodily sensations*"; M4). "*Food affects my thoughts and feelings*"; and M5) "*I notice how food affects my thoughts and feelings*". Participants responded using a 0-100mm line (never/all the time). Higher scores indicate greater perceived levels of aspects of mindfulness.

Mindful attention induction. The MAI script was developed following systematic analyses of the constituent components of published experimental mindfulness inductions and review of current literature (the detailed analysis is in preparation for publication). The MAI script included the identified constituent components: descriptions and practice of mindfulness using breath as an object of focus; bringing attention with a quality of non-reactive and non-judgemental to the observation of self; and used of rhetorical devices. As such the MAI largely followed Kabat-Zinn's (2002) sitting mindful breath awareness meditation used in Verplanken and Fisher (2013). In brief, participants in the Mindful-FCE read a description of mindfulness and then the experimenter read a guided breath awareness meditation in which they were directed to notice arising thoughts, emotions and physical sensations without reaction or judgement.

Control attention condition. In the control condition the presence of the experimenter and effects of being given information in written and oral forms were matched as closely as possible to the format of the MAI. The mindfulness scripts were substituted with a script

describing an exploration of the Venezuelan Rain forest as used in a previous study (Lattimore & Mead, 2015). This Venezuelan Rain forest text was read in the same tone and for the same duration as the mindful attention induction.

Food-cue exposure task. Four high-calorie foods (Cheese and Onion Pringles, Tesco's Rocky Road Clusters, Green and Blacks organic Milk Chocolate, and Mini Twix's) were used as exposure stimuli. The exposure activity was described and "modelled" by the experimenter in a timed procedure based on Jansen et al. (2009). Two pieces of each food item were presented in separate opaque sealed Tupperware. A stopwatch was used to time exposure and a bowl of water and napkin provided to clean fingers between each food item. Participants were instructed to hold and smell each item intensely, touch them against their lips, rotate them between fingers and look intensively at each one. They were told not to eat or taste the food. Participants took a sip of water between food cue exposures.

Procedure

The FFMQ and TFEQ were administered via Bristol Online Survey two weeks prior to the experimental session. To control for readiness to eat participants were asked not to eat or have any caffeinated drinks two hours prior to the experimental session. Participants were tested individually in the laboratory. An overview of participant flow through the procedure and assessments at different stages is provided in Figure 1. On arrival, participants were informed they would be taking part in a "food task" that was being piloted for a different study. After giving informed consent they completed appetite, state mindfulness and mood VAS before random allocation to either the Standard-FCE or the Mindful-FCE group. The Mindful-FCE group completed the MAI, whereas the Standard-FCE listened to information read in the same tone and duration as the MAI. Participants then completed the food-cue exposure task lasting 10 minutes, followed by post-exposure assessment of appetite, state

mindfulness and mood VAS, and of food craving (FCQ). Following post-exposure assessments participants in the Mindful-FCE condition were instructed to practice the mindful breathing meditation taught during the MAI as they were waiting for the next part of the experiment, whereas participants in the Standard-FCE were simply told to reflect on their experience up to that point. During this 10-minute delay period all participants remained in the presence of the cue exposure foods left on a table in their product packaging (unopened). Subsequently, the experimenter returned to inform the participants that the study was almost over and took them to another room to complete end-of-delay appetite, state mindfulness and mood VAS, and measure of food craving (FCQ). Additionally participants completed VAS ratings of their liking and desire to eat cued foods. To maintain the cover story of piloting a food tasting task participants were prompted to provide feedback about the cue-exposure task as an open-ended question. Participants were then given a plate of 12 cookies and a glass of water from which they could have as much as they wanted as 'a token of appreciation and as they had not eaten for two hours and may have to return to work or drive somewhere'. Participants were left unobserved with the cookies for five minutes. Finally, weight and height were measured in a separate room. Participants, having been told the study was completed were asked to suggest what they thought the experiment had been examining. None had disputed the cover story. Suggestions about what the study was measuring included: attention/ concentration/ distraction, the attractiveness of sensory properties of food, and piloting of the food cue procedure. Importantly, no participant suggested that it was about food intake.

Data analysis strategy

Assumptions required for parametric testing were examined prior to any inferential analysis. Parametric test assumptions were met for all analyses with the exception of food intake. Box plots and normality tests indicated that the distributions for the number of

cookies eaten were non-normal with multiple extreme scores in the Standard-FCE condition. A Mann-Whitney test was used, due to the normality violation, to test differences in food intake between the Mindful-FCE and Standard-FCE groups. Analysis of variance (ANOVA) was used to test hypotheses. Where appropriate, Bonferroni corrected t-tests were used to probe significant main effects and interactions. Summary statistics are presented as means (M) and standard deviation of means (SD) unless otherwise stated.

Results:

A series of one way ANOVAs were carried out to examine whether the two groups differed in terms of BMI, age, dispositional mindfulness, uncontrolled eating, emotional eating, cognitive restraint, and time since last eating. No significant differences were found (see Table 1). Two multivariate ANOVAs revealed no significant between-group differences (all $p > .05$) on 1) pre-exposure appetite (hunger, fullness, feeling like eating and desire to eat food) and 2) current mood ratings (happy, relaxed).

Appetitive ratings

To test the hypotheses concerning the overall effects of Mindful-FCE vs Standard-FCE on appetite VAS (hunger, fullness, feeling like eating and desire to eat food) separate 2 (Group: Mindful-FCE vs. Standard-FCE) x 3 (Time: pre vs. post vs. end-of-delay) mixed factorial ANOVAs were conducted (See Table 2). There were no significant main effects of Group on any of the appetite ratings. A significant main effect of Time for hunger showed an increase from pre-cue exposure to post-cue exposure to end-of-delay. Planned comparisons indicated significant differences in hunger pre- to end-of-delay, and post-cue to end-of-delay

297 (*p*s < .05). There were no significant main effects of Time for the remaining appetitive
298 measures.

299 The Time-by-Group interaction for hunger approached significance (p =.076). Based
300 on the hypothesis that compared to the Standard-FCE participants Mindful-FCE participants
301 would experience lower increases in hunger, the Time-by-Group interaction for hunger was
302 investigated. Bonferroni adjusted pairwise comparisons revealed significant increases in
303 hunger pre to post-cue exposure (p=.05) and post-cue to end-of delay (p<.01) for the
304 Standard-FCE group but no significant increases pre to post-cue (p=1.0) and post-cue to end-
305 of delay (p=.06) for the Mindful-FCE group. A significant Time-by-Group interaction was
306 found for fullness. Bonferroni adjusted pairwise comparisons revealed significant increases in
307 fullness pre to post-cue exposure (p=.03) and a significant decrease post-cue to end-of delay
308 (p=.03) for the Mindful-FCE group but no significant changes between pre, post or end of
309 delay for the Standard-FCE group (*ps*>.05). There were no other significant interaction
310 effects.

311 *State craving*

312 To examine the effects of the Mindful-FCE vs Standard-FCE on total scores and
313 subscales of state craving separate 2 (Group: Mindful-FCE vs. Standard-FCE) x 2 (Time: pre
314 vs. post) mixed factorial ANOVAs were conducted. There were no significant main effects or
315 interactions for total scores or subscales of the state FCQ (see Table 3).

316 *Food intake*

317 A Mann-Whitney test on the number of cookies eaten confirmed the hypothesis that
318 the MAI would affect food intake. Significantly fewer cookies were eaten by the Mindful-

FCE group (Range between 0-3; mean = 0.7; *Mdn* = 0) than by the Standard-FCE group (Range between 0-7, M = 2.2; *Mdn* = 2), $U = 69.0, z = -3.7, p<.001, r = -.58$.

State mindfulness

To examine how Mindful-FCE vs Standard-FCE influenced aspects of state mindfulness throughout the experimental session separate 2 (Group: Mindful-FCE vs. Standard-FCE) by 3 (Time: pre vs. post vs. end-of-delay) mixed factorial ANOVAs were conducted. There were no main effects or interactions for responses to the mindfulness items M1, M2 and M3. There was a main effect of Time for item M4: "*Food affects my thoughts and feelings*" ($F(2,76) = 3.53, p < .05, \eta_p^2 = .16$). Bonferroni contrasts ($p = .016$) indicated that food affected participants thoughts and feelings significantly more end-of-delay (M = 69.9 ± 20.7) compared to pre-cue (M = 58.6 ± 21.5). There was no significant difference post-cue (M = 69.9 ± 24.3) vs end-of-delay ($p<.016$). There was also a main effect of Time for item M5: "*I notice how food affects my thoughts and feelings"*, ($F(2,76) = 5.55, p < .01$, $\eta_p^2 = .12$). Bonferroni contrasts ($p = .016$) revealed significant differences between pre-cue (M = 56.9 ± 25.95) and end-of-delay (M = 70.4 ± 23.12; $p < .01$) but no significant differences for the other contrasts ($ps > .016$). There were no significant interaction effects for items M4 and M5.

Ruling out alternative explanations

To rule out that the observed differences in food intake were merely based on liking or the desire to eat at the moment when the cookies were offered, two separate multivariate between subjects ANOVAs (Mindful-FCE vs. Standard-FCE) were conducted on liking and desire to eat VAS for the four cued foods at end-of-delay. There were no significant multivariate effects for liking (Pillai's Trace = .71, $F = .65, df = (4, 34), p > .05$) or desire to eat cued foods (Pillai's Trace = .08, $F = .77, df = (4, 34), p > .05$). To examine whether

changes in mood might contribute to any of the observed mindfulness-specific effects separate 2 (Group: Mindful-FCE vs. Standard-FCE) x 3 (Time: pre vs. post vs. end-of-delay) mixed factorial ANOVAs were conducted for "happy" and "relaxed". There was a significant main effect of Time on relaxed ratings ($F(2,76)= 6.75$, $p<.01$, $\eta_p^2 =.15$). Bonferroni contrasts (adjusted alpha level: $p=.016$) indicated that participants were significantly more relaxed post-cue ($M = 75.23$, $SD = 17.08$) compared to pre-cue ($M = 65.30$, $SD = 14.16$), and end-of-delay ($M = 74.18$, $SD = 18.69$) compared to pre-cue. There was no significant difference post-cue vs end-of-delay ($ps >.016$). There were no significant main effects of Time or Group on happy ratings and, importantly, no time-by-condition interactions for both mood ratings.

Discussion

The present study examined the effects of a brief mindful attention induction on appetitive reactions immediately following exposure to energy-dense food cues, ten minutes post exposure and subsequent food intake. The outcomes partially support our hypotheses. Firstly, the hypothesis that the mindful attention induction would attenuate appetitive reactions to cued foods was confirmed for hunger and fullness. There was no change in hunger and an increase in fullness pre to post exposure following attention with a mindful attitude. In contrast fullness remained the same and hunger increased in the standard attention group. However, desire to eat and feeling like eating were unaffected. Regarding the longevity of effects, the differences in hunger and fullness between groups were not seen ten minutes post exposure. Contrary to expectations there were no between group differences in state craving post-cue exposure or after delay. The hypothesis regarding food intake was wholly supported as the Standard-FCE resulted in significantly more intake compared to the Mindful-FCE. Potential alternative explanations for the observed pattern of differences in appetite measures and intake, such as differences in

liking or desire to eat cued food or in mood, were ruled out as no between-group differences were found.

The effects on subjective hunger and fullness in this sample were short-lived. Participants in both conditions reported comparable levels of hunger, fullness, feeling like eating and craving after the delay period, when given an eating opportunity. Although the two groups did not differ on any of these measures participants in the Standard-FCE group, who brought attention without a mindful attitude to the qualities of foods, ate significantly more than those in the Mindful-FCE group. The current findings support the assertion that mindful attention can disrupt relations between internal experiences and observable behaviours (e.g. Bargh, 1994; Verplanken & Fisher, 2013). These findings differ from Marchiori and Papies (2014) in which a mindfulness exercise (body scan) was shown not to reduce portion size effects but did reduce effects of hunger on unhealthy food choice. However the current study did not compare preferences for healthy/unhealthy food or small/large portions.

The current pattern of results are consistent with mindfulness-based intervention studies evidencing a modulation of the translation of motivational states into eating behaviour (Alberts et al., 2010; Papies et al., 2014) and reduced external eating (Daubenmier et al., 2011). As such this controlled experimental examination of the effect of mindful attention on reactions to exposure to foods may offer insights into underlying mechanisms of effects suggested in previous research (e.g. Daubenmier et al., 2011; Hooper, Sandoz, Ashton, Clarke, & McHugh, 2012). In comparing mindful attention with attention to the properties of cued foods the between-group differences in food intake and post-exposure hunger and fullness can reasonably be attributed to distinctive qualities of mindful attention. However, inferences and suggestions made about the differences in hunger are offered with caution as the interaction did not meet conventional significance levels. One suggestion is that the elicited non-reactive, non-judgemental attitude allowed participants to bring attention to the

sensory properties of cued foods and their reactions reducing the likelihood of reacting automatically. A further explanation for the lack of translation from subjective experience to behaviour following mindful attention is that mindful attention practices influence how thoughts are processed rather than changing the content (Brown et al., 2007). This emphasis on the *how* thoughts are perceived rather than changing the content of thoughts is consistent with findings that the number of cravings experienced is less relevant to the control of eating behaviour than how the cravings are perceived (Hooper et al., 2012). This raises questions as to the importance or value of focusing on the content or number of food related cravings or thoughts when attempting to address the relations between experienced thoughts and behavioural outcomes. There was no difference between the groups in terms of state craving post-cue or prior to the measure of food intake. However craving measures have been shown to be influenced by a mindful attention exercise (noticing, accepting non-judgementally) used in the presence of smoking cues (Westbrook et al., 2013). The current lack of difference may reflect unmeasured differences in state craving pre food-cue exposure rather than the MAI not having an effect on state craving. State craving was not measured pre-cue exposure to avoid participants becoming aware of the experimental hypotheses.

An important conclusion from this study is that a brief mindful attention induction can lead to demonstrable beneficial effects without involving traditional meditation practices, suggesting that such an approach might increase accessibility for people not able, willing or ready to engage more formally with meditation (Mantzios & Wilson, 2015). Further research is required to ascertain the acceptability and practicality of applying mindful attention in this way and if it has the longer term efficacy required to manage weight including the absence of rebound effects (Hooper et al., 2012).

Confidence in attributing effects to the mindful attention induction is increased by the randomised and controlled design and lack of between group differences on measures of

dispositional mindfulness, trait eating patterns (uncontrolled or emotional eating or cognitive restraint) and feelings of relaxedness. Additionally, advertising the study as an examination of food and attention, reduced bias associated with recruiting participants willing to participate in mindfulness meditation experiments. The intention was to minimise the potential for enthusiasm for such practices to create a placebo effect (discussed further in Mantzios & Wilson, 2015). The lack of between-group differences in measured aspects of mindfulness using single item measures may in part reflect a particularly pertinent limitation of self-report measures when considering the accuracy of mindfulness measures: the ability to accurately measure 'mindfulness' is reliant on participants' 'mindfulness'(Grossman, 2011).

Limitations of the study include the laboratory setting, the sample size which limits the statistical power of the analyses, and the representativeness of the sample which limits generalisability. For these reasons, effect sizes are provided to give further information about which findings may be important to pursue in future studies in and out of experimental settings. Further studies are required to ascertain if more enduring effects are only attainable through regular meditation training and if the effects demonstrated in studies such as these differ from that of long term practice. The fact that short-lived effects can be obtained, nevertheless suggests that mindfulness is a powerful and interesting state of consciousness worth further exploration (Verplanken & Fisher, 2013). The current findings indicate that attention with a mindful attitude may promote better eating behaviours in the short-term, and adds to the evidence base justifying the examination of components of mindfulness-based interventions within the context of obesity prevention and management.

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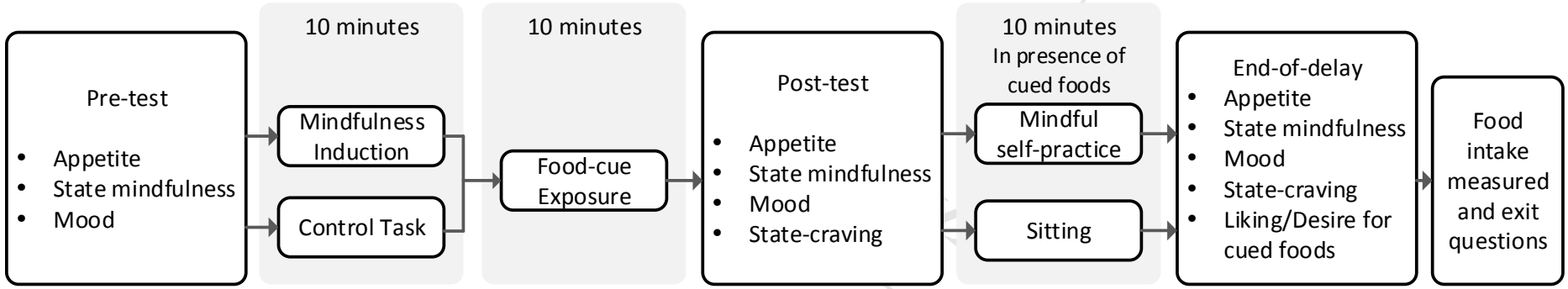

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579 Figure1. Participant flow and assessment points from pre-exposure to post-exposure to end-of-delay and food intake task.

580 Table 1. Baseline measures of individual differences and ANOVA summary values.

		Mindful attention (N = 20)		Attention Control (N = 20)		
	Range	*M*	*SD*	*M*	*SD*	*F(1,38)*
Age	(21- 46)	30.65	9.15	29.50	6.12	.22
BMI (kg/m^2)	(20-39)	25.40	3.72	25.40	4.84	.00
TFEQ-UE	(11-78)	49.07	19.03	43.33	16.25	.37
TFEQ-EE	(0-72)	49.44	32.14	44.16	24.74	2.18
TFEQ-CR	(0-100)	38.05	16.55	46.11	17.94	1.05
FFMQ Total	(95-172)	128.00	17.73	125.55	17.25	.34
Last Ate	(1-15)	3.96	3.29	3.44	3.36	.50

581 Note: TFEQ UE = uncontrolled eating; TFEQ EE = emotional eating; TFEQ CR=
582 cognitive restraint; FFMQ Total= mindfulness; last ate = hours and minutes since last
583 ate.

584 Table 2. Appetite ratings (*M*/*SD*) and ANOVA summary values pre-vs post-cue exposure vs end of delay.

	Mindful attention (N=20)						Attention control (N=20)								
	Pre		Post		End-of - Delay		Pre		Post		End-of - Delay		F(2,76)		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	T	C	T x C
Hungry	54.8	30.1	47.0	26.6	63.1	29.5	44.9	25.2	57.9	22.6	64.4	23.5	5.39* [.28]	.01 [.00]	2.67 [.12]
Full	28.7	21.9	48.0	25.1	33.6	24.8	36.4	22.5	35.4	20.1	34.1	21.8	2.91 [.07]	.08 [.00]	3.16* [.08]
Feel like eating	70.5	17.8	63.0	24.3	67.5	27.6	57.3	25.0	63.8	20.2	67.1	23.0	.68 [.05]	.52 [.01]	2.29 [.08]
Desire to eat food	64.7	23.9	64.6	23.5	68.1	25.2	57.2	25.3	66.9	19.3	68.5	24.3	1.99 [.08]	.07 [.00]	.96 [.04]

585 Note: * p<.05. T = Time main effect; G= Group main effect; T x G= Time-by-Group interaction. Partial Eta squared effect sizes in [].

586 Table 3. General state craving total and subscales post-cue exposure (T2) and end-of -

	Mindful attention (N=20)				Attention control (N=20)						
	Post		End-of - delay		Post		End-of-delay		F(1,38)		
Variable	M	*SD*	M	*SD*	M	*SD*	M	*SD*	T	G	T x G
GSC-total	41.7	13.0	42.4	16.4	42.6	9.8	41.2	11.4	.15 [.00]	.00 [.00]	1.61 [.04]
GSC-IDE	7.3	3.8	7.3	4.1	6.8	2.4	6.7	2.9	0.2 [.00]	.30 [.01]	0.00 [.00]
GSC-ARFN	9.0	2.7	9.0	3.6	8.8	2.6	8.7	2.6	.01 [.00]	.10 [.00]	.01 [.00]
GSC-CPS	8.0	2.6	7.9	3.3	8.5	2.8	8.0	2.9	2.18 [.05]	.09 [.00]	6.33 [.02]
GSC-OPF	9.4	3.4	9.6	3.7	10.5	2.5	10.0	3.3	.37 [.01]	.57 [.02]	2.62 [.07]
GSC-APR	8.0	3.0	8.7	3.4	8.2	2.3	7.9	2.4	.84 [.02]	.15 [.00]	3.73 [.10]

587 delay (T3).

588

589 Note: IDE= Intense desire to eat; ARFN= Anticipation of relief from negative states and feelings;
590 CPS = Craving as a physiological state; OPF= Obsessive preoccupation with food or lack of
591 control over eating; APR= Anticipation of positive reinforcement that may result from eating.
592 Range = the minimum and maximum scores for each subscale and total.

593