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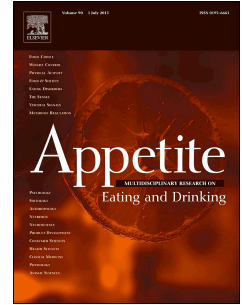
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# Accepted Manuscript

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

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

Article type: Full length Paper

**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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1 Abstract:

2 **Background:** Excessive energy intake that contributes to overweight and obesity is arguably  
3 driven by pleasure associated with the rewarding properties of energy-dense palatable foods.

4 It is important to address influences of external food cues in food-abundant societies where  
5 people make over 200 food related decisions each day. This study experimentally examines  
6 protective effects of a mindful attention induction on appetitive measures, state craving and  
7 food intake following exposure to energy-dense foods.

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

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

20 **Conclusion:**

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

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

25

26

**Introduction**

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

46 2008, 2010; Jansen, Nederkoorn, Van Baak, Kierse, & Guerrieri, 2009). The food-cue  
47 exposure paradigm, a reliable method for examining the effect of exposure to food, has also  
48 been shown to effect subsequent food intake of similar or identical cued foods (e.g., Jansen et  
49 al., 2009; Ferriday & Brunstrom, 2010).

50 Characteristics of the individual (e.g. emotional needs; Evers, Stok, & de Ridder,  
51 2010), food or the food environment may exert influences that individuals may not wholly be  
52 aware of (e.g. Herman & Polivy, 2005; Marchiori & Papies, 2014). Unrecognised somatic  
53 and mental phenomena can trigger automatic reward-motivated behaviours, including eating  
54 (Caldwell, Baime, & Wolever, 2012). The role of automatic habitual tendencies associated  
55 with hedonic hunger are an obstacle to dietary educational approaches (Rothman, Sheeran, &  
56 Wood, 2009). Alternative and complementary approaches are required to understand and  
57 address automatic reward motivated behaviours associated with excessive food intake. In this  
58 respect the concept of mindfulness has received considerable attention (Mantzios & Wilson,  
59 2015). Mindfulness, as defined by Kabat-Zinn (2003) encompasses receptive attention to  
60 whatever arises in the present moment with an open, curious non-judgmental attitude.  
61 Compared to normal functioning a mindful state is one of enhanced receptive awareness and  
62 attention to present reality (Brown & Ryan, 2003). Mindfulness techniques have been shown  
63 to moderate eating behaviours influenced at a perceptual or preconscious level (Kahn &  
64 Wansink, 2004; Wansink, 2010).

65 Mindfulness training interventions have been shown to increase discrimination  
66 between externally cued hunger and hunger associated with emotions (Baer, Fischer, & Huss,  
67 2006), and to attenuate hedonic hunger reducing automatic relations between cravings and  
68 food intake (Alberts, Mulkens, Smeets, & Thewissen, 2010). Increasing awareness and  
69 attention to internal cues and cued responses can serve a “de-automatisation” function (Bargh,  
70 1997; Baumeister, Heatherton, & Tice, 1994; Lattimore & Maxwell, 2004), improve health  
71 outcomes, enable weight regulation (Dalen et al., 2010), and facilitate successful self-  
72 regulation (Papies, Barsalou, & Custers, 2012).

73 In experimental settings mindfulness techniques that increase attention with a mindful  
74 attitude (e.g. non-reactive, non-judgemental) can influence both psychological and  
75 behavioural outcomes (e.g. Arch & Craske, 2006; Erisman & Roemer, 2010; Verplanken &  
76 Fisher, 2013). Specifically, the ability to mindfully observe thoughts and emotions has been  
77 shown to reduce craving (Lacaille et al., 2014), chocolate consumption (Jenkins & Tapper,  
78 2014) and approach responses to appetitive foods (Papies et al., 2012). Under everyday living  
79 conditions the use of a brief mindfulness exercise (see Papies et al., 2012) changed  
80 participants’ levels of hunger so it no longer influenced the attractiveness of unhealthy foods  
81 and eating choices (Papies, Pronk, Keesman, & Barsalou, 2014). In addition to these  
82 mindfulness inductions, the effects of mindfulness practices that are part of standard  
83 mindfulness-based intervention programmes have been investigated. For instance, following  
84 a guided ‘body scan meditation’ (14 minutes), one of the first exercises taught in



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

90         Although research indicates that mindfulness techniques show promise in altering  
91 habitual or automatic eating behaviour there is considerable variation in the content and  
92 structure of techniques used (e.g. Alberts et al., 2010; Forman et al., 2007; Jenkins & Tapper,  
93 2014; Moffitt, Brinkworth, Noakes, & Mohr, 2012). As a consequence caution is required  
94 when interpreting these findings and attributing beneficial effects to mindfulness per se, or to  
95 common practices in mindfulness-based interventions (Grossman & Van Dam, 2011). The  
96 main aim of the current study was to test the influence of mindful attention on eating  
97 behaviour. The “mindful attention induction” (MAI) was developed based on a systematic  
98 review of existing inductions and incorporates key elements of mindful breath awareness  
99 practice (Malinowski, 2013) that is a core technique of multicomponent MBSR programmes  
100 (Brown, Ryan, & Cresswell, 2007; Kabat-Zinn, 1990). The objective of the mindful breath  
101 awareness practice is to foster a state of present moment awareness involving a non-reactive  
102 and non-judgemental attitude. The development of the MAI was motivated by a need to  
103 qualify the use of mindfulness within research, clearly stating how it has been operationalised  
104 or manipulated each context (Davidson, 2010). In doing so this study begins to address the  
105 considerable variation in the use of mindfulness techniques in eating related research. By  
106 combining our MAI approach with an established food-cue exposure methodology this study  
107 examines how brief mindful attention practice may alter habitual or automatic reactivity to  
108 food cues that typically leads to overeating.

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

128

129

**Methods**

## 130 Design

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

## 141 Participants

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

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

## 162 Measures

163 *Pre-exposure control measures.* Dispositional Mindfulness was assessed with the 39-  
164 item Five-Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, &  
165 Toney, 2006) using a five-point Likert scale ranging from “*Never or very rarely true*” to  
166 “*Very often or always true*”. The current study reports the total score as an overall measure of  
167 dispositional mindfulness with higher scores indicating greater dispositional mindfulness  
168 (Baer, Smith, et al., 2006). Internal consistency was satisfactory for the total score ( $\alpha = 0.88$ ).  
169 Eating attitudes relating to hedonic eating behaviour were assessed with the 18-item Three  
170 Factor Eating Questionnaire (TFEQ-R18V2) with subscales measuring uncontrolled eating  
171 (UE), emotional eating (EE), and cognitive restraint (CR; Cappelleri et al., 2009). The four-  
172 point Likert scale ranged from “*Definitely true*” to “*Definitely false*” with responses  
173 transformed to a 0-100 scale in line with common practice for the TFEQ. Higher scores  
174 indicate greater uncontrolled and emotional eating and greater cognitive restraint. Internal  
175 consistency was satisfactory for UE, EE and CR ( $\alpha = 0.83, 0.93, 0.74$  respectively). The  
176 FFMQ, TFEQ, age and BMI recorded by self-report and anthropomorphic measures were  
177 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  $\alpha = 0.77$  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

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

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

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

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

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

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

#### 238 Procedure

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

250 mindfulness and mood VAS, and of food craving (FCQ). Following post-exposure  
251 assessments participants in the Mindful-FCE condition were instructed to practice the  
252 mindful breathing meditation taught during the MAI as they were waiting for the next part of  
253 the experiment, whereas participants in the Standard-FCE were simply told to reflect on their  
254 experience up to that point. During this 10-minute delay period all participants remained in  
255 the presence of the cue exposure foods left on a table in their product packaging (unopened).  
256 Subsequently, the experimenter returned to inform the participants that the study was almost  
257 over and took them to another room to complete end-of-delay appetite, state mindfulness and  
258 mood VAS, and measure of food craving (FCQ). Additionally participants completed VAS  
259 ratings of their liking and desire to eat cued foods. To maintain the cover story of piloting a  
260 food tasting task participants were prompted to provide feedback about the cue-exposure task  
261 as an open-ended question. Participants were then given a plate of 12 cookies and a glass of  
262 water from which they could have as much as they wanted as ‘a token of appreciation and as  
263 they had not eaten for two hours and may have to return to work or drive somewhere’.

264 Participants were left unobserved with the cookies for five minutes. Finally, weight and  
265 height were measured in a separate room. Participants, having been told the study was  
266 completed were asked to suggest what they thought the experiment had been examining.  
267 None had disputed the cover story. Suggestions about what the study was measuring  
268 included: attention/ concentration/ distraction, the attractiveness of sensory properties of  
269 food, and piloting of the food cue procedure. Importantly, no participant suggested that it was  
270 about food intake.

#### 271 Data analysis strategy

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



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

281

282

### Results:

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

#### 289 *Appetitive ratings*

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

297 ( $ps < .05$ ). 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-

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

321

### 322 *State mindfulness*

323 To examine how Mindful-FCE vs Standard-FCE influenced aspects of state  
324 mindfulness throughout the experimental session separate 2 (Group: Mindful-FCE vs.  
325 Standard-FCE) by 3 (Time: pre vs. post vs. end-of-delay) mixed factorial ANOVAs were  
326 conducted. There were no main effects or interactions for responses to the mindfulness items  
327 M1, M2 and M3. There was a main effect of Time for item M4: “*Food affects my thoughts*  
328 *and feelings*” ( $F(2,76) = 3.53$ ,  $p < .05$ ,  $\eta_p^2 = .16$ ). Bonferroni contrasts ( $p = .016$ ) indicated  
329 that food affected participants thoughts and feelings significantly more end-of-delay ( $M =$   
330  $69.9 \pm 20.7$ ) compared to pre-cue ( $M = 58.6 \pm 21.5$ ). There was no significant difference  
331 post-cue ( $M = 69.9 \pm 24.3$ ) vs end-of-delay ( $p < .016$ ). There was also a main effect of Time  
332 for item M5: “*I notice how food affects my thoughts and feelings*”, ( $F(2,76) = 5.55$ ,  $p < .01$ ,  
333  $\eta_p^2 = .12$ ). Bonferroni contrasts ( $p = .016$ ) revealed significant differences between pre-cue ( $M$   
334  $= 56.9 \pm 25.95$ ) and end-of-delay ( $M = 70.4 \pm 23.12$ ;  $p < .01$ ) but no significant differences  
335 for the other contrasts ( $ps > .016$ ). There were no significant interaction effects for items M4  
336 and M5.

### 337 *Ruling out alternative explanations*

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

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

353

354

### Discussion

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

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

371 The effects on subjective hunger and fullness in this sample were short-lived.  
372 Participants in both conditions reported comparable levels of hunger, fullness, feeling like  
373 eating and craving after the delay period, when given an eating opportunity. Although the two  
374 groups did not differ on any of these measures participants in the Standard-FCE group, who  
375 brought attention without a mindful attitude to the qualities of foods, ate significantly more  
376 than those in the Mindful-FCE group. The current findings support the assertion that mindful  
377 attention can disrupt relations between internal experiences and observable behaviours (e.g.  
378 Bargh, 1994; Verplanken & Fisher, 2013). These findings differ from Marchiori and Papies  
379 (2014) in which a mindfulness exercise (body scan) was shown not to reduce portion size  
380 effects but did reduce effects of hunger on unhealthy food choice. However the current study  
381 did not compare preferences for healthy/unhealthy food or small/large portions.

382 The current pattern of results are consistent with mindfulness-based intervention  
383 studies evidencing a modulation of the translation of motivational states into eating behaviour  
384 (Alberts et al., 2010; Papies et al., 2014) and reduced external eating (Daubenmier et al.,  
385 2011). As such this controlled experimental examination of the effect of mindful attention on  
386 reactions to exposure to foods may offer insights into underlying mechanisms of effects  
387 suggested in previous research (e.g. Daubenmier et al., 2011; Hooper, Sandoz, Ashton,  
388 Clarke, & McHugh, 2012). In comparing mindful attention with attention to the properties of  
389 cued foods the between-group differences in food intake and post-exposure hunger and  
390 fullness can reasonably be attributed to distinctive qualities of mindful attention. However,  
391 inferences and suggestions made about the differences in hunger are offered with caution as  
392 the interaction did not meet conventional significance levels. One suggestion is that the  
393 elicited non-reactive, non-judgemental attitude allowed participants to bring attention to the

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

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

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

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

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

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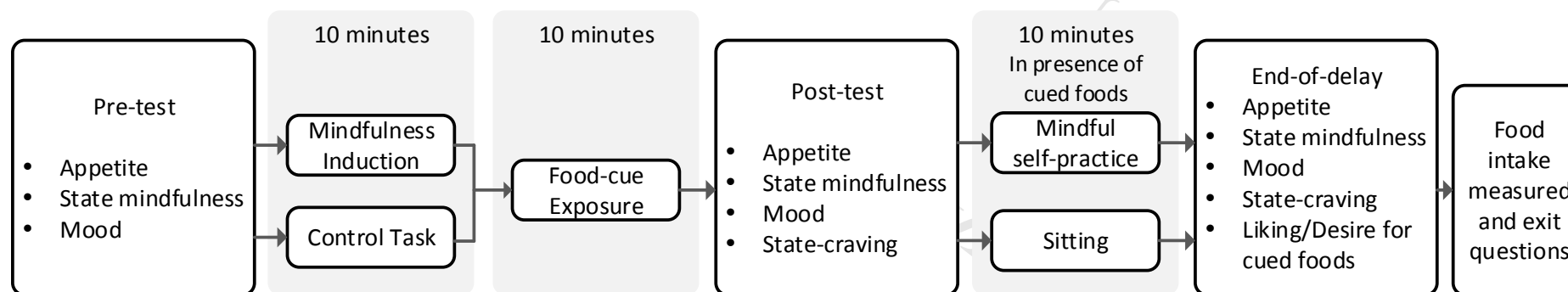
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578

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.

	<i>Range</i>	Mindful attention (N = 20)		Attention Control (N = 20)		<i>F</i> (1,38)
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Age	(21- 46)	30.65	9.15	29.50	6.12	.22
BMI (kg/m <sup>2</sup> )	(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.

Variable	Mindful attention (N=20)						Attention control (N=20)						F(2,76)		
	Pre		Post		End-of - Delay		Pre		Post		End-of - Delay		T	C	T x C
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
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*	.01	2.67
													[.28]	[.00]	[.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	.08	3.16*
													[.07]	[.00]	[.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	.52	2.29
													[.05]	[.01]	[.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	.07	.96
													[.08]	[.00]	[.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 -

Variable	Mindful attention (N=20)				Attention control (N=20)				F(1,38)		
	Post		End-of - delay		Post		End-of- delay				
	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