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Chocolate craving

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5

6 **The effect of visualisation and mindfulness-based decentering on chocolate craving**

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22

23

Abstract

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According to the elaborated intrusion (EI) theory of desire, loading visual working memory should help prevent and reduce cravings because cravings occur when intrusive thoughts are elaborated upon in working memory, often as vivid mental images. Mindfulness-based decentering strategies may also help prevent and reduce cravings since they may divert attention away from craving-related thoughts and mental imagery. To compare the effects of visualisation versus decentering on cravings, participants ($N = 108$) were randomly assigned to one of three conditions: (a) decentering, (b) visualisation, (c) mind-wandering control. Participants in each condition received two audio exercises: (1) a 2-minute exercise, preceding a craving induction but after initial deprivation and cue exposure, (2) a 4-minute exercise, following a craving induction. The audios instructed participants to look at a plate of chocolate that was in front of them whilst either (a) decentering from their thoughts and feelings, (b) engaging in visualisation or (c) letting their mind wander. Participants were asked to rate the strength of their cravings at four time points (Time 1, baseline; Time 2, after the 2-minute audio; Time 3, post-craving induction; Time 4, post-4 minute audio). Frequency of craving-related thoughts was also measured at Time 4. Compared to the control condition, results showed a significant reduction in strength of cravings for the decentering condition after both the 2-minute audio and the 4-minute audio. Decentering was superior to visualisation only after the 2-minute audio. Participants in both the visualisation and decentering conditions also had significantly lower frequencies of craving-related thoughts compared to control participants. The findings support EI theory and suggest that mindfulness-based decentering strategies may be useful for both the prevention and reduction of cravings. Pre-registration: <https://osf.io/jv3pq>

Keywords: mindfulness; mindful eating; decentering; craving; visualisation; elaborated intrusion theory

1. Introduction

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Craving refers to a subjective motivational state that compels a person to consume a particular substance, such as alcohol or drugs, but also food (Baker et al., 1986; May et al., 2015; Shiffman, 2000). Chocolate is thought to be the most widely craved food in the Western world, particularly among women (Erskine & Georgiou, 2013). For most people, occasional food cravings occur without causing any problems (Lafay et al., 2001). However, if cravings become maladaptive, they may lead to disordered eating, including binge eating (Ng & Davis, 2013), low mood and depression (Davis et al., 2011), as well as health problems associated with obesity (von Deneen & Liu, 2011).

The elaborated intrusion theory of desire (EI theory) is a cognitive model that specifies two stages to the development of a craving: intrusion and elaboration (Kavanagh et al., 2005; May et al., 2015). EI theory describes how intrusive thoughts about food occur when a person associates their eating with certain cues. These cues could be internal, such as feeling tired or stressed, or external, such as walking past a bakery on the morning commute or seeing certain foods in the supermarket (Kavanagh et al., 2005; Sun & Kober, 2020; Tapper, 2018). These cues trigger intrusive thoughts about food that may then be elaborated upon in limited capacity working memory systems, most frequently through the sensory modalities of taste, smell and sight (Tiggemann & Kemps, 2005). It is this elaboration that leads to a feeling of craving, which can also interfere with other cognitive tasks (Kavanagh et al., 2005).

Researchers interested in managing food cravings have often targeted the elaboration stage in order to reduce their strength after they have occurred. Effective strategies include those that interrupt elaboration by competing for visuospatial working memory (Kavanagh et al., 2005; May et al., 2010; May et al., 2012), for example, with visual tasks such as Tetris (Skorka-Brown et al., 2014), dynamic visual noise (Kemps et al., 2004), or imagining non-food scenes (e.g., a rainbow; Harvey et al., 2005), and spatiomotor control tasks such as clay modelling (Andrade et al., 2012). Guided imagery, or visualisation, has also been shown to reduce craving intensity for self-reported chocolate cravers (Experiment 2, Schumacher et al., 2017) and a general student population (Hamilton et al., 2013).

Another way in which the elaboration stage has been targeted is through the use of decentering. Decentering is a mindfulness-based strategy where thoughts and feelings are

86 viewed as transient mental events that are separate from oneself (Bishop et al., 2004; Lebois
87 et al., 2015). Decentering may interrupt craving-related elaboration by diverting attention
88 away from craving-related mental imagery. For example, if imagery relating to the taste of
89 chocolate is followed by an awareness of this imagery as simply ‘thoughts’, it may in turn be
90 followed by other more general thoughts, such as healthy eating related goals (Tapper &
91 Ahmed, 2018). Several studies have supported the view that decentering can reduce craving
92 strength (Schumacher et al., 2018; Tapper, 2018).

93
94 An alternative approach to managing cravings is to target the intrusion stage in order to
95 prevent craving-related intrusive thoughts from being elaborated, in full, or at least with less
96 intensity. According to EI theory, this should weaken craving development. Again, both
97 visualisation and decentering strategies could achieve this by loading visual working memory
98 and/or helping to divert attention elsewhere. Although there is limited research specifically
99 examining the effects of these strategies on the intrusion stage of craving, several studies
100 have found significant effects on cravings and consumption outside the laboratory and it is
101 possible that such effects were in part brought about by weakening craving development (as
102 opposed to reducing craving strength once it had occurred; Jenkins & Tapper, 2014;
103 Schumacher et al., 2018; see also Tapper, 2018).

104
105 Few studies have directly compared the effects of visualisation versus decentering. One
106 exception is Schumacher et al. (2017) who, across two studies, looked at the effects of these
107 strategies on craving reduction (i.e., after a craving induction). Study 1 recruited a general
108 sample whilst Study 2 recruited habitual chocolate cravers. Compared to a control condition,
109 they found reductions in craving strength for the decentering group in both studies, but in the
110 visualisation group craving reduction only occurred in the second study. In a subsequent field
111 study (Schumacher et al., 2018) they found that both visualisation and decentering were
112 effective at reducing craving frequency and intensity over a 7-day period.

113
114 However, decentering strategies typically also include elements of visualisation. Thus an
115 important limitation of these studies is that it is difficult to rule out the possibility that the
116 effects of decentering occurred simply because of the visualisation element. Tapper and
117 Turner (2018) attempted to address this issue by using visualisation and decentering
118 strategies that were matched for visualisation. Using 4-minute audio exercises, they looked at

Chocolate craving

119 the effects of (1) decentering, (2) visualisation, and (3) mind wandering (control) on
120 chocolate cravings following a craving induction. However, there was a reduction in cravings
121 across all conditions with no significant differences between conditions. Nevertheless,
122 exploratory analyses showed that decentering was more effective than visualisation when
123 overall task adherence was high.

124

125 The present study aimed to extend this research by looking at the effects of decentering and
126 visualisation on both craving development (i.e., pre-craving induction) as well as craving
127 reduction (i.e. post-craving induction). Specifically, we examined the effects of decentering
128 and visualisation on craving both prior to and following a craving induction, targeting the
129 intrusion and elaboration stages of craving. Additionally, and in contrast to Tapper and
130 Turner (2018), we asked participants to keep their eyes open rather than closed during the
131 decentering and visualisation exercises; we felt this might better reflect the type of strategy
132 that could be more readily employed in daily life, for example in the office, at a party or
133 when passing the supermarket's confectionary aisle.

134

135 Thus the first aim of the study was to compare the effects of decentering and visualisation on
136 craving development. In other words, after initial deprivation and cue exposure, but before a
137 more intense craving induction. We predicted a smaller increase in the strength of chocolate
138 cravings for visualisation compared to mind wandering (Hypothesis 1a) and for decentering
139 compared to mind wandering (Hypothesis 1b). Because the decentering and visualisation
140 strategies were matched for visualisation (i.e., the decentering strategy incorporated both
141 visualisation and decentering), we also predicted a smaller increase in strength of cravings for
142 decentering compared to visualisation (Hypothesis 1c).

143

144 The second aim was to test the effects of decentering and visualisation on craving reduction.
145 In other words, after participants had undergone a more intense craving induction. We
146 predicted a larger decrease in strength of chocolate cravings for visualisation compared to
147 mind wandering (Hypothesis 2a) and for decentering compared to mind wandering
148 (Hypothesis 2b). Again, because the decentering and visualisation strategies were matched
149 for visualisation, we also predicted a larger decrease in strength of cravings for decentering
150 compared to visualisation (Hypothesis 2c).

151

Chocolate craving

152 The third aim was to test the effects of the two strategies on the frequency of chocolate
153 cravings following the craving induction (i.e., during the craving reduction stage). We
154 predicted a lower frequency of chocolate cravings for visualisation compared to mind
155 wandering (Hypothesis 3a) and for decentering compared to mind wandering (Hypothesis
156 3b). As before, we also predicted a lower frequency of cravings for decentering compared to
157 visualisation (Hypothesis 3c).

158

159 The final aim was to test the moderating effect of self-reported task adherence on the
160 relationship between the conditions and craving strength, after the craving induction (i.e.,
161 during the craving reduction stage). We predicted that the effect of condition on craving
162 strength would be greater with higher levels of task adherence. Hypothesis 4a compared
163 visualisation with mind wandering, Hypothesis 4b compared decentering with mind
164 wandering and Hypothesis 4c compared decentering with visualisation. The study
165 hypotheses, method and analysis plan were pre-registered at <https://osf.io/jv3pq>

166

167

2. Methods

168

2.1. Participants

169
170 Participants were 108 females ($n = 63$) and males ($n = 45$) with a mean age of 26.7 years (SD
171 $= 9.6$; range = 18 - 67 years), who responded to adverts seeking ‘chocolate lovers’ interested
172 in research on managing cravings for sugary foods such as chocolate bars. Participants across
173 three London universities were recruited via posters placed around the university buildings,
174 adverts on university websites and student newsletters, and the social media accounts of the
175 first author. Participants were offered compensation for their time of £5 and/or the chocolate
176 bar selected during the craving induction. Inclusion criteria were aged 18 years or over and
177 consumption of chocolate at least 4 times per month. Exclusion criteria were a current
178 diagnosis of an eating disorder, pregnancy, and medication or health conditions (e.g.,
179 allergies, diabetes) that would prevent them from fasting for 2 hours or from eating sugary
180 snacks. The target sample size was 36 participants per condition. This was informed by
181 Tapper and Turner (2018) who used the same scale in relation to chocolate craving. It
182 assumed a mean baseline craving of 16 out of 30 ($SD = 7$) and was powered to detect a mean
183 difference of 5 in craving level between conditions. Ethical approval was received by City,
184 University of London Psychology Department Research Ethics Committee in March 2019.

185

186 **2.2. Craving induction**

187 Following Kemps and Tiggemann (2007), a combination of deprivation and cue exposure
188 were used to induce chocolate cravings. This occurred in two stages, to induce the occurrence
189 and elaboration of intrusive craving-related thoughts at different levels of intensity. In the
190 first stage (Time 1), a plate of four wrapped chocolate products (Dairy Milk, 45g; Snickers,
191 48g; Bounty, 57g; three Lindor truffles, 40g total) were placed in front of participants, to the
192 left of the computer, with an empty plate placed directly in front of them. These chocolates
193 were visible as soon as the participant entered the room. The second stage (after Time 2) was
194 a more intense craving induction that utilised more sensory modalities; participants were
195 instructed to choose their favourite type of chocolate from the plate, unwrap it, smell it, and
196 place it with its wrapper on the empty plate directly in front of them. They were instructed
197 not to eat the chocolate. If the Lindt chocolate was selected, participants were asked to
198 unwrap all three pieces. Participants were asked to select the name of the chocolate they had
199 chosen and, using a visual analogue scale from 0-100, rate how much they liked it (from 0 =
200 *not at all* to 100 = *very much*) and how much they felt like eating it (from 0 = *no desire or*
201 *urge* to 100 = *extreme desire or urge*).

202

203 **2.3. Experimental manipulation**

204 Participants in all three conditions listened to 2-minute and 4-minute audio recordings with
205 instructions modified from Tapper and Turner (2018). In the visualisation and decentering
206 conditions participants were asked to imagine themselves sitting in a forest by a stream. In
207 the decentering condition they were asked to imagine placing any thoughts or feelings onto a
208 leaf and watch it float down the stream (Hayes, 2005, pp. 76-77 ; Rogers & Hardman, 2015).
209 In the visualisation condition they were simply asked to imagine watching the leaves float by.
210 In the control condition, participants were asked to let their mind wander. The opening and
211 closing instructions were identical across all three conditions (e.g., ‘sit back and relax but
212 keep your eyes on the chocolate’; ‘you can now look around the room’), and the number and
213 timings of all other audio instructions were matched across the conditions. Participants were
214 asked to keep their eyes open throughout the experimental manipulation. (See Supplementary
215 Files for scripts).

216

217 **2.4. Measures**

218 **2.4.1. Hunger.** Participants were asked to ‘indicate how hungry you feel right now’
219 using a sliding scale from 0 (*not at all hungry*) to 100 (*extremely hungry*). They were also
220 asked to indicate when they last ate and when they next expected to eat, though in light of
221 Rogers and Hardman (2015) we subsequently excluded these as indices of hunger.

222

223 **2.4.2. Craving.** Strength and frequency of craving-related thoughts were assessed
224 using the intensity sub-scales of the Craving Experience Questionnaire-Strength (CEQ-S;
225 May et al., 2014) and Craving Experience Questionnaire-Frequency (CEQ-F; May et al.,
226 2014). The CEQ-S and CEQ-F both have sub-scales relating to intensity, imagery and
227 intrusiveness. In this study, the intensity sub-scale of the CEQ-S was used to measure current
228 strength of cravings at four intervals. The sub-scale comprises three items scored from 0 (*not*
229 *at all*) to 10 (*extremely*): ‘Right now, how much do you WANT chocolate?’; ‘Right now,
230 how much do you NEED chocolate?’; ‘Right now, how strong is the urge to have
231 chocolate?’. The intensity sub-scale of the CEQ-F was used once to measure craving
232 frequency and comprises three items also scored from 0 (*not at all*) to 10 (*extremely*):
233 ‘During the 4-minute audio recording, how often did you WANT chocolate?’; ‘During the 4-
234 minute audio recording, how often did you NEED chocolate?’; ‘During the 4-minute audio
235 recording, how often did you have a strong urge for chocolate?’. In a previous study on
236 chocolate cravings (Andrade et al., 2012), the CEQ scales have been shown to have high
237 internal reliability: CEQ-S ($\alpha = .93$), CEQ-F ($\alpha = .97$). In the current study, the scales also
238 showed good internal reliability: CEQ-S (α ranged between .83 – .88 across Time 1 to Time
239 4), CEQ-F ($\alpha = .91$).

240

241 **2.4.3. Task adherence.** As per Tapper & Turner (2018), participants were asked to
242 report on two measures of task adherence: how well they followed the instructions during the
243 4-minute audio recording (‘overall adherence’) and if they were still following the
244 instructions towards the end of the 4-minute audio recording (‘end adherence’). Both
245 measures were scored from 0 (*not at all*) to 10 (*all of the time*). Additionally, an open-ended
246 question asked what they were thinking about during the audio recording. The measure of
247 end adherence and the open-ended question were included as exploratory measures.

248

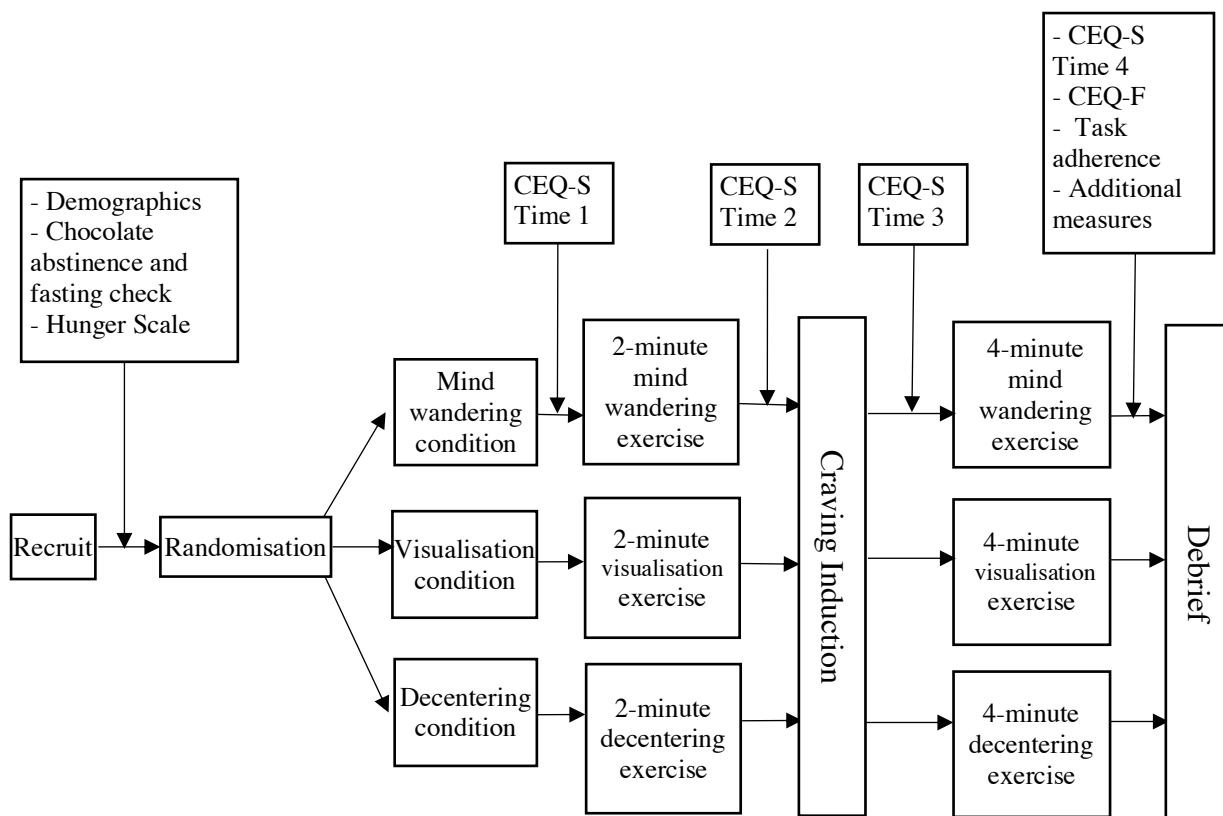
249 **2.5. Procedure**

250 Participants meeting the eligibility criteria were offered a 30-minute appointment at the
251 university and were asked to refrain from eating chocolate products for 24 hours prior to this
252 time. They were also asked to abstain from eating or drinking anything other than water for 2
253 hours prior to the appointment. The experiment was delivered using Qualtrics, an online
254 survey software that collected all measures and randomised participants to one of the three
255 conditions, stratifying by gender (see Figure 1).

256

257 Testing took place in a quiet room. Participants were first asked to report their gender, age
258 and first language, and whether they had eaten any chocolate products in the past 24 hours, or
259 any food or drink other than water in the past 2 hours. If they answered yes to either of these
260 questions, they were asked to specify what they had eaten and when. They then completed
261 measures of hunger and the CEQ-S (Time 1), before being randomised to one of the three
262 conditions (decentering, visualisation or control) and listening to the relevant 2-minute audio.
263 They then completed the CEQ-S for the second time (Time 2), underwent the craving
264 induction, followed by the CEQ-S (Time 3). After this they listened to the 4-minute audio for
265 their allocated condition (decentering, visualisation or control) and completed the CEQ-S for
266 a fourth and final time (Time 4). Finally, participants completed the CEQ-F and task
267 adherence measures as well indicating whether or not they were dieting to lose weight. They
268 also completed exploratory measures of stress and self-esteem that are not discussed in this
269 article.

270



271

272 **Figure 1.** Flow diagram of study procedures. CEQ-S = Craving Experience Questionnaire-
 273 Strength. CEQ-F = Craving Experience Questionnaire-Frequency. Additional measures not
 274 reported here.

275

276

3. Results

277

3.1. Participant characteristics

279 As shown in Table 1, more people in the visualisation condition were dieting to lose weight
 280 and adhered to the 24-hour chocolate abstinence instructions. This group also had lower
 281 baseline levels of craving and hunger but were slightly less likely to have adhered to the 2-
 282 hour fasting instructions. Baseline levels of current craving were similar across the three
 283 conditions. Gender and age were well-matched across conditions.

284

285

286 **Table 1.** Characteristics of Study Participants in Each Condition

287

Characteristic	Decentering (<i>n</i> = 36)	Visualisation (<i>n</i> = 36)	Control (<i>n</i> = 36)
Percentage of females	58%	58%	58%
Age (<i>M</i> , <i>SD</i>)	27.8 (11.5)	26.0 (8.5)	26.3 (8.7)
Percentage dieting to lose weight ^a	11%	22%	11%
Percentage adhering to chocolate abstinence instructions	72%	83%	61%
Percentage adhering to fasting instructions	94%	86%	94%
Hunger score (<i>M</i> , <i>SD</i>)	58 (23)	52 (25)	60 (26)
Strength of current chocolate cravings (CEQ-S) at baseline (<i>M</i> , <i>SD</i>) ^b	15 (7)	13 (6)	15 (8)

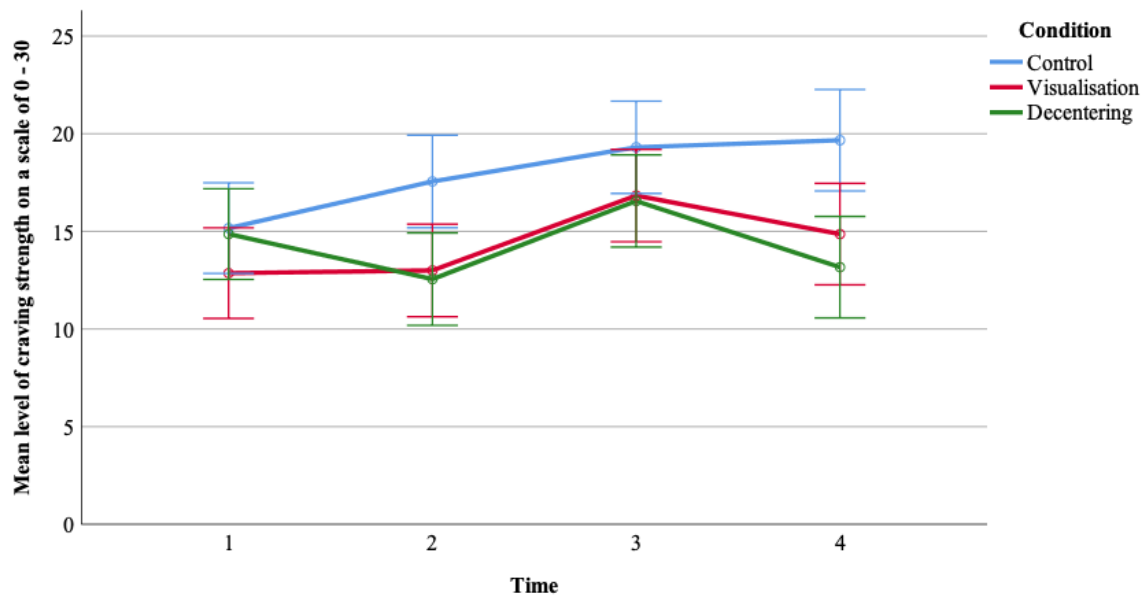
288 Note. CEQ-S = Craving Experience Questionnaire-Strength

289 ^a Declined to say: Decentering (*n* = 2), Visualisation (*n* = 1), Control (*n* = 1).290 ^b CEQ-S scores could range from 0 – 30.

291

292 **3.2. Effects on strength of cravings**

293 To explore craving development (i.e., after initial deprivation and cue exposure, but before an
 294 intense craving induction), a 2 (time) x 3 (condition) mixed ANOVA on strength of cravings
 295 at Times 1 and 2 showed no significant main effects of time, $F(1, 105) = 0.03, p = .858, \eta_p^2 =$
 296 0.00 , or condition, $F(2, 105) = 2.55, p = .083, \eta_p^2 = 0.05$. However, as predicted there was a
 297 significant interaction between time and condition, $F(2, 105) = 10.73, p < .001, \eta_p^2 = 0.17$,
 298 (see Figure 2).



299

300 **Figure 2.** Mean levels of strength of cravings in the three conditions, at four time points.
 301 Note. Error bars: 95% Confidence Interval

302

303

304 To explore this interaction, change scores (from Time 1 to Time 2) were computed for each

305 of the three conditions. These were $M = -2$ ($SD = 5$) for decentering, $M = 0$ ($SD = 5$) for

306 visualisation and $M = 2$ ($SD = 3$) for control. As predicted, follow-up t -tests showed

307 significant differences between the decentering and control conditions, $t(52.17) = 5.02$, $p <$

308 $.001$, $d = 0.97$, between the visualisation and control conditions, $t(52.69) = 2.44$, $p = .018$, $d =$

309 0.49 , and between the decentering and visualisation conditions $t(70) = 2.10$, $p = .040$, $d =$

310 0.40 .

311

312 To explore craving reduction (i.e., after the more intense craving induction), a 2 (time) x 3

313 (condition) mixed ANOVA on strength of cravings at Times 3 and 4 showed a significant

314 main effects of time, $F(1, 105) = 13.12$, $p < .001$, $\eta_p^2 = 0.11$, and condition, $F(2, 105) = 4.21$,

315 $p = .017$, $\eta_p^2 = 0.07$. As predicted, there was also a significant interaction between time and

316 condition, $F(2, 105) = 5.64$, $p = .005$, $\eta_p^2 = 0.10$. Again, change scores (between Times 3 and

317 4) were computed for each condition to explore this interaction: decentering, $M = -3$ ($SD =$

318 5); visualisation, $M = -2$ ($SD = 5$); control, $M = 0$ ($SD = 4$). As predicted, follow-up t -tests

319 revealed significant differences between the decentering and control conditions ($t(65.38) =$

320 3.63 , $p = .001$, $d = 0.66$) and between the visualisation and control conditions ($t(70) = 2.10$, p

321 = .039, $d = 0.44$). Contrary to predictions, there was no significant difference between the
322 decentering and visualisation conditions ($t(70) = 1.15, p = .253, d = 0.20$).

323

324 **3.3. Effects on frequency of cravings**

325 Mean frequency of cravings (Time 4) was 12 ($SD = 8$) in the decentering condition, 13 ($SD =$
326 8) in the visualisation condition and 18 ($SD = 9$) in the control condition. A one-way
327 between-groups ANOVA found a significant effect of condition, $F(2, 105) = 4.70, p = .011,$
328 $\eta_p^2 = 0.08$. Follow-up t -tests showed that, as predicted, craving frequency was lower in the
329 decentering and visualisation conditions compared to the control condition; $t(70) = 2.87, p =$
330 $.005, d = 0.70$ and $t(70) = 2.32, p = .023, d = 0.59$ respectively. However, contrary to
331 predictions, there was no significant difference between the visualisation and decentering
332 conditions; $t(70) = 0.55, p = .586, d = 0.13$.

333

334 **3.4. Moderating effects of task adherence**

335 Mean overall task adherence (Time 4) was 7 ($SD = 2$) in the decentering group, 7 ($SD = 2$) in
336 the visualisation group, and 9 ($SD = 1$) in the control group. A one-way ANOVA showed
337 these were significantly different; $F(2,105) = 18.97, p < .001, \eta_p^2 = 0.27$.

338

339 Two hierarchical regression models were used to estimate the moderating effect of overall
340 task adherence on the effect of condition on change in strength of cravings between Time 3
341 and Time 4. Overall task adherence was entered at Step 1, condition at Step 2, and the
342 interaction term at Step 3. The dependent variable was change in craving score between Time
343 3 and Time 4. In the first model the experimental conditions (decentering/visualisation) were
344 compared with the control condition (experimental = 1, control = 0) whilst in the second
345 model the decentering condition was compared with the visualisation condition (decentering
346 = 1, visualisation = 0). Contrary to predictions, neither model showed an interaction between
347 condition and overall task adherence (first model: $b = -0.44, SE B = 0.74, \beta = -0.31, p = .555;$
348 second model: $b = 0.52, SE B = 0.74, \beta = 0.36, p = .480$).

349

350 Exploratory analysis also examined end adherence scores (decentering: $M = 7, SD = 2;$
351 visualisation: $M = 7, SD = 2;$ control, $M = 9, SD = 1$). When end adherence scores were used
352 in the models described above, these showed a significant interaction when the experimental

353 conditions were contrasted with the control condition ($b = -1.27$, $SE B = 0.63$, $\beta = -0.93$, $p =$
354 $.045$), but not when the decentering condition was contrasted with the visualisation condition
355 ($b = 0.98$, $SE B = 0.54$, $\beta = -0.68$, $p = .076$). Simple slopes analysis on centred variables
356 showed that when end adherence was low (1 SD below the mean), there was no effect of
357 experimental versus control condition on change in craving ($b = -0.02$, 95% CI [-4.31, 4.26];
358 $t = -0.01$, $p = .991$). However, at mean levels of end adherence, and when end adherence was
359 high (1 SD above the mean), there were greater reductions in craving in the experimental
360 conditions compared to the control condition ($b = -2.74$, 95% CI [-5.22, -0.25]; $t = -2.18$, $p =$
361 $.031$ and $b = -5.45$, 95% CI [-8.02, -2.89]; $t = -4.21$, $p < .001$ respectively). The Johnson-
362 Neyman method indicated that the transition point occurred when end adherence was -0.14
363 SDs below the mean, with all scores above this showing a significant effect of condition on
364 craving change.

365

366

4. Discussion

367

368 The results showed that both decentering and visualisation reduced craving strength and
369 frequency following a craving induction. These findings are in line with a number of previous
370 studies (Hamilton et al., 2013; Schumacher et al., 2017; Tapper, 2018). They are also
371 consistent with EI theory that predicts that these strategies will interfere with the process of
372 elaboration which underpins cravings (Kavanagh et al., 2005; May et al., 2015). The results
373 of the present study also extend previous research by showing that both decentering and
374 visualisation were able to weaken the development of cravings. This may be because the
375 strategies prevented intrusive thoughts from being elaborated upon, either partially or in full.
376 Ultimately, targeting cravings at this earlier stage in their development may be a more
377 effective strategy for two reasons. First, it may prevent the development of very strong
378 cravings and so may reduce the likelihood of cravings leading to consumption. And second, it
379 may be easier for a person to choose to engage in decentering or visualisation at this point;
380 according to EI theory, craving-related imagery is initially pleasurable, thus once a person
381 reaches the elaboration stage they may be less inclined to engage in decentering or
382 visualisation. This interpretation is consistent with the fact that our results also showed that
383 decentering and visualisation were not effective at reducing cravings when participants
384 reported low adherence to these strategies. Future research would benefit from comparing
385 levels of strategy adherence during craving development versus craving reduction.

386

387 An important strength of the current study is that, like Tapper and Turner (2018),
388 visualisation was matched across the visualisation and decentering conditions. Since
389 decentering strategies tend to include elements of visualisation, this matching allows more
390 confidence that any extra advantage gained by the decentering strategy was due to the
391 decentering elements, rather than just additional visualisation. The results showed that the
392 decentering strategy was indeed more effective than visualisation when used to weaken
393 craving development (i.e., following cue exposure but prior to a craving induction). We
394 speculate that this may be because decentering increases the accessibility of other thoughts
395 and goals that are important to the individual, some of which may be incompatible with
396 satisfying the craving (Tapper & Ahmed, 2018). This in turn may help motivate the
397 individual to continue with the strategy and keep their attention diverted away from craving-
398 related imagery. However, other interpretations are possible, in particular, the grounded
399 cognition theory of desire states that decentering works by reducing the subjective realism of
400 intrusive craving-related thoughts and mental imagery (Papies et al., 2011). Further research
401 would be needed to distinguish between these two accounts.

402

403 However, in contrast to the above findings, and to Schumacher et al. (2017), there was no
404 evidence to indicate that decentering was superior to visualisation at reducing craving
405 following an intense craving induction that utilised multiple sensory modalities. Further
406 research using Bayesian analysis could help confirm the absence or presence of a difference
407 in efficacy between the two strategies at this point in the craving process.

408

409 An additional strength of our study was that we asked participants to keep their eyes open
410 whilst engaging in the two strategies. This is in contrast to Tapper and Turner (2018) where
411 participants were asked to close their eyes and where equivalent levels of craving reduction
412 were seen across all three conditions (i.e., in a mind wandering control condition as well as in
413 the decentering and visualisation conditions). Whilst many previous studies do not indicate
414 whether participants were directed to keep their eyes open or closed, it is possible that
415 strategy effects only emerge when participants' eyes are open and when the food item is
416 maintained within their field of vision, making intrusive thoughts more likely. Where a
417 participant closes their eyes or diverts their gaze away from the food it may become easier for
418 those in the control condition to employ their own effective strategies. For example, in

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419 Tapper and Turner, participants in the control group reported thinking about things such as
420 course assignments or their plans for the rest of the day; thoughts that were likely sufficiently
421 engaging to prevent craving-related elaboration. From an applied perspective, a strategy that
422 allows one to keep one's eyes open is also likely to be easier to implement in everyday life.

423
424 Nevertheless, the study had a number of limitations that are important to highlight. First,
425 although craving levels at Time 1 were well matched between the control and decentering
426 groups, they were numerically lower in the visualisation group. At Times 3 and 4, the effects
427 of the strategies on craving reduction are also more difficult to interpret since participants had
428 already employed their assigned strategy during the development stage and levels of craving
429 were higher among control group participants compared to those in the experimental groups.
430 To address this issue, future research would benefit from assessing effects on craving
431 development and craving reduction on separate occasions.

432
433 Second, the study did not include any follow-up measures of craving. For example,
434 Schumacher et al. (2017), measured craving at three time points, with the final measurement
435 taking place 10 minutes after the experimental manipulation. This type of follow-up measure
436 would help explore the extent to which reductions in craving can be maintained over time and
437 would help rule out any rebound effects. This may be particularly important given that levels
438 of craving appeared to rise more steeply during the craving induction phase (between Times
439 2 and 3) among those in the decentering and visualisation conditions.

440
441 Third, we did not include a measure of consumption so cannot be sure of the extent to which
442 differences in cravings would translate into differences in consumption. Other research has
443 shown that reductions in cravings do not always lead to reductions in consumption
444 (Schumacher et al., 2017). Additional research is needed to explore this further as well as
445 examine the effects of these strategies on craving and consumption outside the laboratory;
446 research by Schumacher et al. (2018) indicates that decentering and visualisation strategies
447 similar to those used in the present study can reduce both levels of craving and consumption
448 outside the laboratory.

449
450 Finally, in contrast to many previous studies on food cravings, we included males in our
451 sample as well as females. Although females reportedly experience stronger food cravings

452 than males (Hormes et al., 2014), craving management may be just as important for men who
453 are attempting to lose weight or quit other substances such as cigarettes. It is therefore
454 important that the study of craving amongst males is not neglected. Although our study was
455 not powered to examine sex differences in the efficacy of these strategies for craving
456 management, this could be usefully explored in future research.

457

458 In summary, the results of this study add to a growing body of literature that suggests that
459 decentering strategies may be helpful for managing cravings as well as achieving healthy
460 eating and weight loss goals (Caselli & Spada, 2016; Jenkins & Tapper, 2014; Lacaille et al.,
461 2014; Papies & Barsalou, 2015; Tapper, 2017, 2018; Tapper & Ahmed, 2018). Given the
462 simplicity of the decentering strategy used in the current study, it would also be relatively
463 easy to incorporate it into existing weight management and healthy eating interventions.

464

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466

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468

469 **Author contributions**

470

471 EW contributed to study design, collected the data, took the lead on data analysis and wrote
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473 analysis and wrote sections of the paper. All authors contributed to data interpretation and to
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475

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481 **Conflict of interest**

482

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484

485 **References**

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486

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