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

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Abstract

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

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

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

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

2. Methods

168

2.1. Participants

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 (α = .93), CEQ-F (α = .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 (α = .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
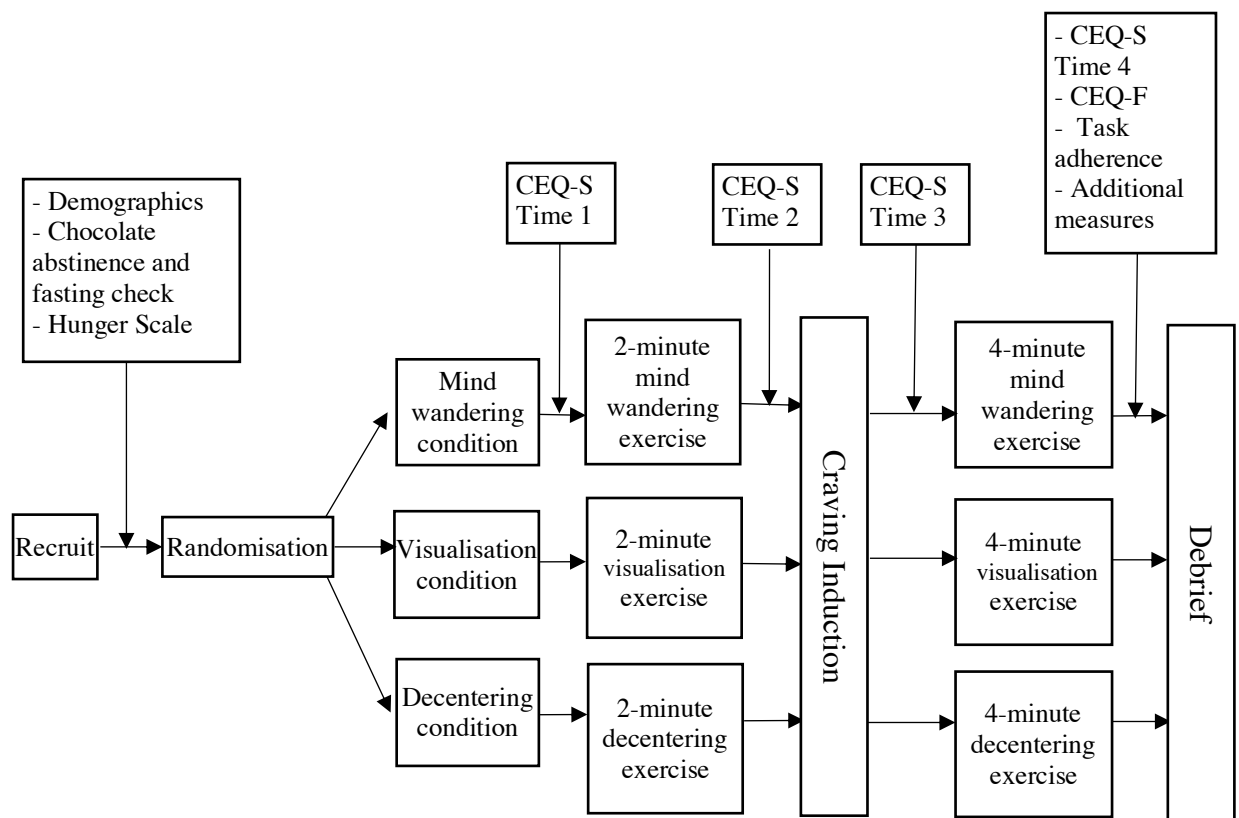
269 article.

270

271

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

275

3. Results

277

3.1. Participant characteristics

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

284

285

286 **Table 1.** Characteristics of Study Participants in Each Condition
287

Characteristic	Decentering (*n* = 36)	Visualisation (*n* = 36)	Control (*n* = 36)
Percentage of females	58%	58%	58%
Age (*M*, *SD*)	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 (*M*, *SD*)	58 (23)	52 (25)	60 (26)
Strength of current chocolate cravings (CEQ-S) at baseline (*M*, *SD*) [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

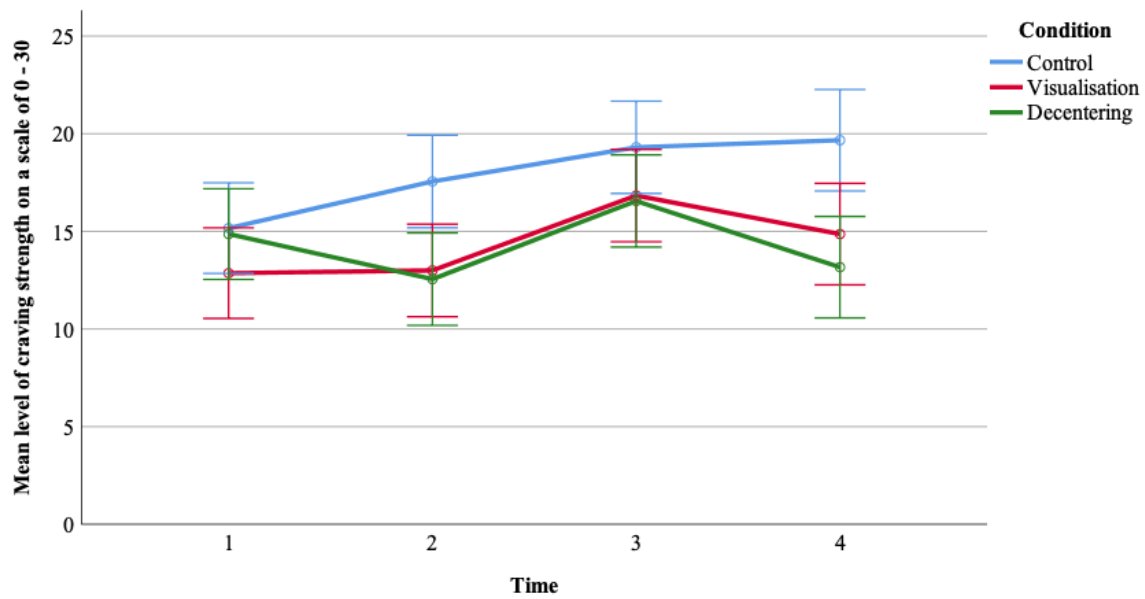297 significant interaction between time and condition, $F(2, 105) = 10.73$, $p < .001$, $\eta_p^2 = 0.17$,

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

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

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, β = -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, β = -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

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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468

Author contributions

470

471   EW contributed to study design, collected the data, took the lead on data analysis and wrote

472   the first draft of the manuscript. KT took the lead on study design, contributed to data

473   analysis and wrote sections of the paper. All authors contributed to data interpretation and to

474   the final version of the manuscript.

475

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Conflict of interest

482

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484
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