

Manipulations of attention during eating and their effects on later snack intake

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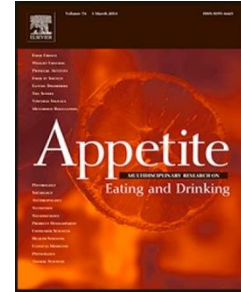
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1 **Appetite**

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6 **Manipulations of attention during eating and their effects on later snack intake**

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10

11 Running header: attention, memory and food intake

12

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20 Key words:

21 Cognitive; attention; memory; Environmental stimuli; food intake;

22

23 Highlights

- 24 • Distraction during eating increased later snacking and reduced meal memory
- 25 • The effect of distraction was larger when motivation to engage with the distracter
26 was greater
- 27 • The effect of distraction was offset when the distracter included food-related cues
- 28 • Focusing attention during eating decreased later snacking

29
30 Abstract: Manipulation of attention during eating has been reported to affect later
31 consumption via changes in meal memory. The aim of the present studies was to examine
32 the robustness of these effects and investigate moderating factors. Across three studies,
33 attention to eating was manipulated via distraction (via a computer game or TV watching)
34 or focusing of attention to eating and effects on subsequent snack consumption and meal
35 memory were assessed. The participants were predominantly lean, young women students
36 and the designs were between-subjects. Distraction increased later snack intake and this
37 effect was larger when participants were more motivated to engage with the distracter and
38 were offset when the distracter included food-related cues. Attention to eating reduced
39 later snacking and this effect was larger when participants imagined eating from their own
40 perspective than when they imagined eating from a third person perspective. Meal memory
41 was impaired after distraction but focusing on eating did not affect later meal memory,
42 possibly explained by ceiling effects for the memory measure. The pattern of results
43 suggests that attention manipulations during eating have robust effects on later eating and
44 the effect sizes are medium to large. The data are consistent with previous reports and add
45 to the literature by suggesting that type of attention manipulation is important in
46 determining effects on later eating. The results further suggest that attentive eating may be
47 a useful target in interventions to help with appetite control.
48

49 INTRODUCTION

50

51 It is increasingly being recognised that memory for recent eating plays an important
52 role in appetite (Higgs 2002; Higgs et al. 2012; Martin and Davidson 2014;
53 Brunstrom 2014). Indeed, the flexibility of human eating behaviour may be
54 underpinned by our ability to use information about past eating events to inform
55 future eating behaviour. It has been reported that manipulating memories for recent
56 eating affects future consumption decisions (for reviews see Higgs 2005; 2008). For
57 example, boosting memories of recent eating via explicit recall of the last meal
58 reduces food intake (Higgs 2002; Higgs, Williamson and Attwood, 2008a). On the
59 other hand, amnesic patients, who are unable to remember eating, eat multiple meals
60 in quick succession (Hebben et al. 1895; Rozin et al. 1999; Higgs et al. 2008b).
61 Furthermore, inducing a false memory of what has been eaten has been found to
62 influence appetite in the inter-meal interval (Brunstrom et al. 2012). In line with the
63 view that an important function of memory is to be able to more reliably predict the
64 future by utilising past experience, these results suggest that memories formed during

65 eating are factored into to future decisions about when and how much to eat, probably
66 because they allow for efficient prediction about whether consumption of food is
67 likely to be rewarding (Higgs 2015; Martin and Davidson 2014).

68

69 There have been several investigations of how manipulation of the attention paid to
70 food as it is eaten affects later consumption via changes in meal memory. If attention
71 is drawn away from eating by providing participants with the opportunity to watch
72 television or play a computer game while eating, these distracted participants will eat
73 more later than participants who were not distracted during eating (Higgs and
74 Woodward, 2009; Mittal et al. 2011; Brunstrom et al. 2011). Conversely, if
75 participants are encouraged to focus on food while they are eating then they will eat
76 less than participants who were asked to eat as usual (Higgs and Donohoe 2011;
77 Robinson et al. 2014). Importantly, these effects of distraction or attentive eating on
78 snack intake are observed even though all participants consume the same lunch meal.
79 The effects are also observed in the absence of effects of the attention manipulation
80 on rated mood or hunger or eating rate. Moreover, the evidence suggests that the
81 effects are related specifically to changes in measures of meal memory.

82

83 While the effects of manipulating attention paid to eating on later intake appear to be
84 robust (Robinson et al. 2013a), there has been little investigation of the factors that
85 may moderate these effects. The aim of the studies presented here was to **replicate the**
86 **basic effects** and examine 1) whether the amount of attention paid to eating affects
87 later consumption and 2) whether the type of attention manipulation alters the size of
88 the effect. In Study, 1 the level of distraction away from eating was manipulated by
89 providing an incentive to play a computer game while eating. It was hypothesised that

90 paying participants would increase the amount of attention paid to playing the game
91 and hence reduce the amount of attention paid to eating. It was further hypothesised
92 that participants who were paid to play the game would show a larger increase in later
93 snacking than participants who were not paid to play the game (or who were not
94 distracted by a game). In Study 2, the type of TV programme watched during eating
95 was manipulated. Participants either watched a programme that contained no
96 reference to eating, or they watched a food-related programme that involved
97 preparation of a food similar to that being eaten. It was hypothesised that the non-
98 food-related distractor would have a greater effect to increase later intake than the
99 food-related distractor. **It was reasoned that the presence of the food being consumed
100 in the TV programme might act as cue to trigger thoughts and images of the food
101 being eaten which would offset somewhat the generally distracting effects of TV
102 watching. Hence, it was hypothesised that the overall effect of watching food-related
103 TV would be intermediate between the effects watching non-related TV and not
104 watching any TV programme.** Finally, the effect of attentive eating on later snacking
105 was examined and we manipulated whether the participants focused on the meal from
106 their own perspective or from the perspective of another person. Here, it was
107 hypothesised that there would be a greater effect of attentive eating to reduce later
108 consumption when participants were asked to imagine themselves eating the meal
109 versus when they were asked to imagine someone else (a celebrity) eating the meal.
110 This was because of evidence that self-referential thinking leads to enhanced memory
111 and imagining an event from a personal perspective makes that event particularly
112 memorable (Grilli & Glisky 2010; Symons, & Johnson, 1997).

113

114 Methods

115 Study 1

116 Participants

117 The participants were 39 normal weight young women students (mean age = 20,
118 standard deviation (SD) 1.7 years, mean BMI = 22, SD 2.4) from the School of
119 Psychology, University of Birmingham, who took part in the study in return for
120 course credits. We restricted our sample to women only because males tend to take
121 advantage of the opportunity to eat as much as possible in these kinds of studies and it
122 is hard to recruit enough men from a predominantly female cohort of students (Mittal
123 et al., 2011). Eating habits were assessed by the Dutch Eating Behavior
124 Questionnaire (DEBQ, (Van Strien et al., 1986). Scores for emotional eating (mean =
125 2.6, SD = 1.0), restrained eating (mean = 2.7, SD = 0.9) and external eating (mean =
126 3.4, SD = 0.5) were within the normal range. The sample comprised the first 39
127 volunteers who met the study's requirements. So that participants were not alerted to
128 the specific purpose of the experiment, recruitment to the study was via an
129 advertisement describing the experiment as a study of meal environments on
130 subsequent food taste preferences. Participants gave informed written consent and the
131 study protocol was approved by the University Research Ethics Committee and
132 conducted according to the ethical standards laid down in the Declaration of Helsinki
133 1964.

134

135 Experimental design

136 Participants were randomly assigned to one of three experimental conditions: the high
137 distraction group where the participants were told a monetary reward was available
138 for the most wins in the game that week, a low distraction group where the

139 participants were instructed to play the game without an incentive and a control group
140 where participants ate their lunch with no game as a distraction.

141

142 Test foods

143 Lunch. The lunch consumed by the participants was the same in all conditions.

144 Participants were asked to consume a fixed lunch of several food items presented in a
145 fixed order (see Table 1 **for the foods and order of presentation**). The reason for this
146 was so that the order of consumption of the lunch items could be tested for recall later.
147 The lunch contained approximately **400** calories. 300 ml of still mineral water was
148 also provided.

149

150 Afternoon snack. Three plates of cookies were provided. The cookies were:

151 Sainsbury's Basics (Sainsbury's, UK) chocolate chip cookies (496 calories per 100g),
152 custard creams (496 calories per 100g) and nice biscuits (485 calories per 100g).

153 Approximately 80 g of each cookie type was presented on a separate plate for each
154 cookie type and the cookies were broken into bite size pieces to reduce the likelihood
155 that participant would keep count of the number of cookies consumed. 300 ml of still
156 mineral water was provided

157

158 Computer game.

159 The computer game used in the distraction conditions was an online helicopter game
160 requiring the participants to fly a helicopter and dodge obstacles in a tunnel just using
161 the left mouse button (<http://www.helicoptergame.net/>). This allowed them to eat the
162 lunch with their other hand.

163

164 Procedure

165 Each test day comprised two sessions: the first session took place between 12.00 and
166 1.30 p.m and the second between 1.30 and 3.00 p.m. Upon arrival for the first test
167 session (the lunch session), the participant was seated individually at a table in a quiet
168 room and asked to complete a series of line rating scales assessing mood and appetite.
169 The following items were rated using a 100 mm unmarked line rating scale with “Not
170 at all” and “Extremely” as end anchors and the question “How XXX do you feel right
171 now?”: hungry, full, bloated, relaxed, irritable, alert, happy and sad (centred above the
172 line). Ratings were obtained by measuring the distance in mm from the left extremity
173 of the lines. Before the lunch the participants in the high distraction condition were
174 reminded of the monetary reward available to the person with the most wins that
175 week. Participants in the low distraction condition were told to play the computer
176 game for the duration of the lunch session. Participants in the no distraction group
177 received no instructions. Participants were asked to consume all of the food provided.
178 They had access to water 300ml, which they could drink ad libitum. Participants in
179 the distraction conditions began playing the computer game and started the first item
180 of an eight item lunch. They proceeded to play the computer whilst eating each food
181 item during 90 second intervals in the order specified. A timer signalled each 90
182 second interval. Each food item was enclosed in a container with a number on the
183 cover. The participants were instructed to eat the food in numerical order. Pilot testing
184 confirmed that each food item could be consumed in the 90 second interval. The total
185 lunch duration was 15 minutes. Once the lunch had been consumed the same set of
186 rating scales were completed. Participants in the two distraction conditions completed
187 an additional rating scale asking “how motivated were you towards the computer
188 task?”. The scale was anchored by “not at all” and “extremely” on a 100-mm line.

189 This was used as a manipulation check to assess whether there was a difference
190 between the distraction groups in level of motivation towards the computer task. The
191 participants were instructed not to consume any food in between the lunch time
192 session and the snack tasting session and to return in an hour.

193

194 At the beginning of the second test session (the tasting session), the participant was
195 asked to rate her appetite and mood using the line rating scales described previously.
196 The participant was instructed to taste and rate each type of biscuit in order of letter
197 type using the sheets provided. Each sheet consisted of scales assessing nuttiness,
198 sweetness, liking and choice. In line with the cover story participants were
199 encouraged to take their time tasting each biscuit, eating as much or as little as they
200 wanted. They were instructed to clear their mouth as fully as possible before moving
201 on to the other variety of biscuit. On the experimenter's return, a final set of scales
202 were completed assessing mood hunger, thirst, fullness and desire to eat. The
203 participants then recalled the serial order of the lunch items. Participants were also
204 then asked to rate how vividly they could remember the lunch that they ate earlier
205 using a 100 mm line rating scale anchored "not at all vividly" and "extremely
206 vividly". At the end of the second test day, participants were asked to write down their
207 thoughts on the aim of the experiment. Height and weight were measured and the
208 participants then completed the Dutch Eating Behaviour Questionnaire (Van Strien et
209 al., 1986). Each participant was thanked, asked to refrain from discussing the study
210 with other students and told that debriefing would be by e-mail at a later date. The
211 amount of cookies consumed by each participant was calculated by weighing the
212 plates before and after the taste test.

213

214 Methods

215 Study 2

216 The general methods for Study 2 were similar to those described for Study 1 and so
217 only variations in the methods are described.

218

219 *Participants*

220 The participants were 63 normal weight young women students (mean age=19.7
221 years, SD = 3.5 years, BMI =22.1, SD=3.4) from the School of Psychology,
222 University of Birmingham. The experiment was advertised as a study about mood and
223 eating.

224

225 *Experimental Design*

226 A between-subjects design was used and participants were randomly allocated to one
227 of three lunch conditions: watching a food-related TV clip (TV food condition),
228 watching a non-food-related TV clip (TV condition) or watching no TV at all (control
229 condition).

230

231 *Tests Foods*

232 *Lunch Session*

233 The same lunch was consumed by all participants. It consisted of one 300g tin of
234 Heinz Cream of Tomato Soup (171 kcal) heated to 71°C and one slice of Kingsmill
235 50/50 Medium Sliced Bread from an 800g bag cut into eighths (94 kcal). 200ml of tap
236 water was provided.

237

238 *Snack Session*

239 Three types of biscuits were provided for participants to taste. 100g each of McVities
240 chocolate digestives (495 kcal per 100g), Cadbury's milk chocolate fingers (520 kcal
241 per 100g) and Maryland chocolate chip cookies (487 kcal per 100g).

242

243 *TV clips*

244 The TV clip was a video of Jamie Oliver making tomato soup, 'Oliver's Twist'
245 (<http://www.tubechop.com/watch/1850690>) lasting 8 minutes 16 seconds. A clip from
246 'Homes Under the Hammer' (<http://www.youtube.com/watch?v=MgstQLDkaQk>)
247 lasting 8 minutes 24 seconds was rated most similar to 'Oliver's Twist' in terms of
248 how interesting, funny and entertaining it was in a pilot study and so was chosen as
249 the non-food TV clip.

250

251 *Procedure*

252 The experiment comprised two sessions both lasting 30 minutes. The lunch session
253 took place between 12:00 and 2:30pm and the snack session between 2:30 and
254 5:30pm. Participants were asked to refrain from eating for at least two hours before
255 the first session. After arriving for the lunch session, participants were seated alone in
256 a quiet room and asked to complete mood and appetite rating scales. Participants were
257 then given lunch and had nine minutes to eat it whilst watching either a food-related
258 TV clip, a non-food-related TV clip or not watching TV. All participants were asked
259 to finish the lunch and those watching TV were told to pay close attention to the clip
260 because they would later be asked some questions about it. After finishing the lunch,
261 participants completed the mood and appetite scales again. They also completed
262 scales to assess their liking for the lunch which asked, 'How much did you like the
263 lunch you ate?' and 'How much would you like to eat this type of food again?'

264 Participants in the TV conditions then answered a quiz designed to assess whether
265 they had watched the TV clip and were sufficiently distracted by it. Before leaving,
266 participants were reminded to attend the afternoon snack session, scheduled for 2.5
267 hours later that day and were asked to refrain from eating before the second session.
268 Upon arrival at the snack session, participants completed the mood and appetite rating
269 scales again. They then took part in a taste test; they were presented with three types
270 of chocolate biscuits and to encourage consumption, they were informed that they
271 could eat as many as they wished as they had to be thrown away after their
272 participation (Higgs & Woodward, 2009). Participants were left for 10 minutes to rate
273 the biscuits for how crunchy, sweet, nutty and salty the biscuits were and how much
274 they liked their taste and texture. They completed a rating scale which asked, 'How
275 vivid is your memory of the lunch?'. Participants' eating habits were then assessed by
276 the restraint subscale of the DEBQ and the disinhibition subscale of the Three-Factor
277 Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985). Participants' height and
278 weight were then measured to calculate BMI. Participants were then asked to write
279 down what they thought the study was about. They were then debriefed, asked to
280 refrain from discussing the study with their peers and thanked for their participation.

281

282 Study 3

283 The general methods for Study 3 were similar to those described for Study 1 and 2
284 and so only variations in the methods are described.

285

286 Participants

287 45 undergraduate students took part in the study (38 females and 7 males). The mean
288 age of participants was 19 years ($SD= 0.97$), with a mean BMI of 21.9 ($SD= 3.16$).

289 The mean dietary restraint score (DEBQ) was 2.0 (SD= 0.79) and the mean tendency
290 towards disinhibition (TFEQ) score was 6.3 (SD= 2.81).

291

292 Design

293 The study had a between-subjects design and there were three conditions: 1) a self-
294 imagining condition, in which participants were instructed via an audio clip to
295 imagine they were watching themselves eat 2) an imagining-celebrity condition, in
296 which participants were instructed, again via an audio clip, to imagine they were
297 watching a celebrity (David Beckham) eat, and 3) a control condition, who were just
298 instructed to eat their lunch without a manipulation.

299

300 Materials

301 Audio clips

302 There were two different audio clips used in this study. Both were approximately
303 three minutes long. Both clips involved instructing the participant to imagine they
304 were an observer. For participants in the self-imagining condition, the clip asked them
305 to imagine they were able to watch themselves eat in the room, whilst for participants
306 in the imagining-other condition the clip asked them to imagine they were watching
307 David Beckham eat in the room. Celebrity imagery was used as it has been found that
308 imagining a close other has the same effect as self-imagining (Hamami, Serbun &
309 Gutchess, 2011), so by using a celebrity image this should be more distant to the self.
310 The clip started with instructing the participant to imagine they are able to watch
311 either them self or David Beckham in the room they are sitting in and asks the
312 participant to make a clear image in their head of their surroundings. The clip then
313 moves on to instructing them to imagine they are able to watch either them self or

314 David Beckham eat the lunch. The clip is said in a neutral tone and is said slowly with
315 several pauses to allow the participant to imagine the scene.

316

317 Lunch

318 A lunch consisting of 8 items was given to each participant. The foods given are
319 shown in Table 2.

320 Each food item was enclosed in an airtight container with a number on the top. All
321 participants were given the same set lunch to eat, and these lunch items were given in
322 the same order each time. 300ml of still water was also provided in a glass to all
323 participants.

324

325 Afternoon snack

326 For the afternoon snack session three different biscuits were used: McVitie's
327 digestives (McVities & Price Ltd, Edinburgh, UK, 495 calories per 100g), Maryland
328 chocolate chip cookies (Burton's food Ltd., Merseyside, UK, 511 calories per 100g),
329 and Cadbury's milk chocolate fingers (Burton's food Ltd., Merseyside, UK, 520
330 calories per 100g). Each type of biscuit was placed in a different glass bowl, with
331 approximately 60g of each cookie type being used.

332

333 Procedure

334 Participants attended two sessions which both took part in the same day. The first
335 session took place between 12-2pm and the second session took place approximately
336 two hours later between 2-4pm. Each session lasted approximately 20 minutes.

337 Participants were instructed not to eat for two hours before the study. In the first
338 session, participants were then seated and baseline measurements of appetite and

339 mood were taken. Participants then ate a fixed lunch consisting of eight items. All
340 participants ate these in the same order. Participants were left alone for ten minutes
341 while eating the lunch. For the self-imagining and imagining-other conditions,
342 participants listened to a three minute audio clip through headphones which instructed
343 them to either imagine they were watching themselves eat or a celebrity eat,
344 respectively. Participants in the control condition had their lunch in silence.
345 Participants then completed the appetite and mood scales again. Participants were
346 then able to leave the lab and were instructed not to eat during the break between the
347 two sessions. On their return in the second session, participants then completed the
348 appetite and mood scales. Participants were then given the three plates of cookies and
349 were left for ten minutes to taste the cookies and rate them on some visual analogue
350 scales. Before being left alone, participants were told to eat as many cookies as they
351 liked as the cookies would be thrown away afterwards. After the ten minutes had
352 passed, participants filled out another appetite and mood scale. They then were asked
353 to rate the vividness of their memory for the lunch they had earlier and were
354 instructed to write down the order in which they ate it. They were also told to write
355 down briefly what they believed about the purpose of the study. Finally, participants'
356 completed the DEBQ and TFEQ and their height and weight were then measured and
357 they were thanked for their participation and were told that they would be debriefed
358 by e-mail.

359

360 Analyses

361 Since the effects of attention during eating on later intake has been reported
362 previously our aim was to provide a further test of the reliability of the effects and to
363 investigate whether the effect size differs according to variation in the type of

364 attention manipulation. In keeping with the new approach to statistics and to aid
365 future meta-analyses we report estimates and effect sizes for the main results of
366 interest (Cummings 2013).

367

368 RESULTS

369 Study 1

370 Participant characteristics

371 Table 3 shows the characteristics of the sample for Study 1. All participants were
372 young women in the normal BMI range.

373 Biscuit intake

374 Intake was highest in the high distraction condition (mean = 36.2 g; 95% confidence
375 interval (CI) = [26.8,45.6]), and lowest in the control condition (mean = 21.4 g 95%
376 confidence interval (CI) = [12,30.8]). Intake for the low distraction group was in
377 between the two other conditions (mean = 29.8 g 95% confidence interval (CI) =
378 [20.3,39.2]). The effect size for the comparison between the control and high
379 distraction condition was large Cohen's $d = 0.87$ and the effect size for the
380 comparison between the low distraction condition and the control condition was
381 medium Cohen's $d = 0.6$. See Figure 1a.

382

383 Memory measures

384 For the memory recall, serial order accuracy was highest in the control condition
385 (mean = 7.3/8 items 95% confidence interval (CI) = [6.4,8.3], and lowest in the high
386 distraction condition (mean = 5.6/8 items, 95% confidence interval (CI) = [4.6,6.5],
387 with the low distraction condition intake being in between the two (mean = 7.1/9
388 items, 95% confidence interval (CI) = [6.1,8.1]). The effect size for the comparison

389 between the control and high distraction condition was large Cohen's $d = 1.1$ and the
390 effect size for the comparison between the low distraction condition and the control
391 condition was medium Cohen's $d = 0.6$.

392

393 Memory vividness ratings were highest in the control condition (mean = 80, 95%
394 confidence interval (CI) = [67,92], and lowest in the high distraction condition (mean
395 = 61, 95% confidence interval (CI) = [49,74], with the low distraction condition
396 ratings being in between the two (mean = 66, 95% confidence interval (CI) = [54,79].
397 The effect size for the comparison between the control and high distraction condition
398 was large Cohen's $d = 1$ and the effect size for the comparison between the low
399 distraction condition and the control condition was medium Cohen's $d = 0.6$.

400

401 Manipulation check and confounders: the motivation rating was higher in the high
402 distraction group (mean = 7.3, 95% confidence interval (CI) = [6.4,8.1] than the low
403 distraction group (mean = 6.2, 95% confidence interval (CI) = [5.4,7.1] and this
404 contrast was a medium effect size Cohen's $d = 0.7$. No participants guessed the aim of
405 the study and mood ratings did not differ between groups.

406

407 Study 2

408 Participant characteristics

409 Table 4 shows the characteristics of the sample for Study 2. All participants were
410 young women in the normal BMI range.

411

412 Biscuit intake

413 Intake was highest in the TV condition (mean = 82.8g; 95% confidence interval (CI)
414 = [65.8,99.8]), and lowest in the control condition (mean = 67.4g, 95% confidence
415 interval (CI) = [50.3,84.5]). The food TV condition intake was in between the two
416 other conditions (mean = 74.7g 95% confidence interval (CI) = [57.7,91.8]). The effect
417 size for comparison between the control and TV condition was **small** Cohen's $d = 0.4$
418 and the effect size for the comparison between the food TV condition and the control
419 condition was small Cohen's $d = 0.2$. See Figure 1b.

420

421 Memory measures

422 Memory vividness ratings were highest in the control condition (mean = 69.4, 95%
423 confidence interval (CI) = [62,77], and lowest in the TV condition (mean = 62, 95%
424 confidence interval (CI) = [54,69], with the food TV condition intake being in
425 between the two (mean = 63, 95% confidence interval (CI) = [55,71]). The effect sizes
426 were medium for both the high and low distraction conditions compared with the
427 control but smaller in the food TV condition: Cohen's $d = 0.5$ and 0.4 respectively.

428

429 Manipulation check and confounders: Both the TV groups had similar scores on the
430 questionnaire about the content of the TV programmes, suggesting that they were
431 equally distracting while differing in the specific content. Mean score for the food TV
432 group was 3 out of 5 correct 95% confidence interval (CI) = [2.7,3.5] and mean
433 scores for the TV group was 3 out of 5 correct 95% confidence interval (CI) =
434 [2.7,3.5]. No participants guessed the aim of the study and mood ratings did not differ
435 between groups.

436

437 Study 3

438 Participant characteristics

439 The sample was predominantly young women in the normal BMI range (See Table 5).

440 A few male participants were also tested but they were not analysed separately due to
441 the small numbers. The pattern of results was similar for males and females and so the
442 overall means and effect sizes are presented.

443

444

445

446 Biscuit intake

447 Intake was highest in the control condition (mean = 80g, 95% confidence interval (CI)
448 = [66.2,93.8]), and lowest in the self-imagining condition (mean = 56g, 95%
449 confidence interval (CI) = [42.2,69.8]). The celebrity-imagining condition intake was
450 in between the two other conditions (mean = 62.5g, 95% confidence interval (CI) =
451 [48.7,76.3]). The effect size for the comparison between the control and self-imagining
452 condition was large Cohen's $d = 0.9$ and the effect size for the comparison between
453 the celebrity-imagining condition and the control condition was medium Cohen's $d =$
454 0.6. See Figure 1c.

455

456 Memory measures

457 For the memory recall, accuracy was similar in all conditions and was close to ceiling
458 (mean control condition = 7.6/8 items 95% confidence interval (CI) = [7.1,8], mean
459 celebrity-imagining condition = 7.6/8 items, 95% confidence interval (CI) = [7.1,8.0],
460 mean self-imagining condition = 7.6/9 items, 95% confidence interval (CI) = [7.2,8].

461 The effect sizes were negligible.

462

463 Memory vividness ratings were lowest in the celebrity-imagining condition (mean =
464 76.5, 95% confidence interval (CI) = [68.6,84.4] but similar in the self-imagining
465 condition (mean = 80.6, 95% confidence interval (CI) = [72.7,88.6], and control
466 condition (mean = 82.5, 95% confidence interval (CI) = [74.6,90.4]. The contrast
467 between the control and celebrity-imagining condition was medium, Cohen's $d = 0.5$
468 **and the contrast between the control and self-imagining condition was small**, Cohen's
469 $d = 0.1$.

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481 DISCUSSION

482 In three studies, attention paid to food while it was being eaten was manipulated and
483 the effects on later intake and meal memory were assessed. Despite differences in the
484 type of lunch eaten (e.g. buffet versus soup) and the type of attention manipulation
485 (e.g. computer game playing versus TV watching), a clear pattern of results was
486 observed. Distraction during eating increased later snack intake while focusing on

487 food decreased later snack intake. These effects were large and are consistent with
488 previous reports (Higgs and Woodward, 2009; Higgs and Donohoe 2011; Brunstrom
489 et al. 2011; Mittal et al 2011; Robinson et al. 2014). Distraction during eating
490 impaired later meal memory whether it was assessed by serial recall of the order in
491 which foods were eaten or a measure of meal memory vividness. However, enhancing
492 attention towards food was not associated with better meal memory as assessed by a
493 rating of memory vividness.

494

495 In Study 1, the effects of distraction during eating were enhanced if there was an
496 incentive to engage with the distracting computer game. There was also a greater
497 effect on meal memory in the incentivized condition than in the non-incentivized
498 condition. These data suggest that greater motivation to engage with the computer
499 game reduced attention paid to the meal, which may have resulted in greater later
500 intake and poorer meal memory. The effect sizes for intake and meal memory were
501 both large, which supports the suggestion that changes in memory processes underlie
502 the effects of distraction on later eating.

503

504 In Study 2, the distracting effects of TV were offset somewhat when the TV
505 programme contained images of the food being consumed by the participants. One
506 reason for this may be that the food images provided a cue to the participants to focus
507 on their own meal **by prompting thoughts and images of the food being eaten**, which
508 reduced the impact of TV watching on meal encoding. These data suggest that the
509 content of a distracting TV programme may influence meal memory encoding. Mittal
510 et al. (2011) did not find differential effects of watching a boring, sad or funny TV
511 programme on later intake. It may be that the mood inducing effects of TV do not

512 affect later intake, but other content related factors, such as the presence or absence of
513 food, are influential. In line with this suggestion, Higgs and Donohoe (2011) reported
514 that reading a newspaper article about food during lunch did not increase later snack
515 intake relative to a no distraction control condition. It may be that the presence of
516 food-related cues during distraction is sufficient to keep the participants interested
517 enough in their own eating to offset the effects of distraction on memory. In order to
518 test whether the effects observed in Study 2 are specifically related to the participants
519 paying more attention to the food they were consuming in the food-TV condition, it
520 will be necessary to examine whether watching a TV programme about food
521 generally, and not just the food being eaten, has similar effects.

522

523 In Study 3, we replicated the previously reported finding that focusing on food while
524 eating reduces later snack intake (Higgs and Donohoe 2011; Robinson et al. 2014).
525 Participants who were instructed via audio clip to imagine themselves eating the meal
526 ate fewer snacks later than participant who ate without any such instructions. We
527 further found the effects of imagining eating were reduced if participant imaged
528 eating from a third person perspective. The use of the self-imagination versus other-
529 imagination task is useful because it controls for the general demands of the procedure
530 such as effects on eating rate, hedonic appreciation and demand awareness. It is also a
531 useful manipulation from the point of view of the role of memory in eating because
532 there is evidence that memories are better encoded if event is seen from a personal
533 perspective (Grilli & Glisky 2010; Symons, & Johnson, 1997). One explanation for
534 the present pattern of results is that intake was reduced after lunch because the self-
535 imagining task led to a better meal memory than the celebrity-imagining and control
536 tasks. However, we found no evidence that meal memory was enhanced in either of

537 the imagining conditions. This may be because there were no effects of the
538 manipulation on memory encoding, but perhaps more likely, because there were
539 limitations to the memory measure used that precluded observing significant effects.
540 While decreases in meal memory have been demonstrated consistently, increases in
541 memory have proved harder to observe. For example, Robinson and colleagues (2014)
542 also found no effects of focusing on food while eating on later meal memory, despite
543 observing a reduction in intake. In the Robinson and colleagues study (2014), and the
544 studies here, meal memory in the control condition was near perfect and so it may be
545 that ceiling effects prevented any effects of memory enhancement being detected.
546 This suggests that future research should be directed at developing more sensitive
547 measures that are capable of detecting both decreases and increases in meal memory.
548 In addition, other possible explanations for the effect of “attentive eating” on later
549 intake that do not relate to memory should be explored.

550

551 The experiments presented in this paper suggest consistent and large effects of
552 manipulating attention during eating on later intake. However, there are limitations to
553 the methods that should be discussed to inform future research in the area. First, the
554 samples tested are very homogenous and consist **predominantly** of young women of
555 normal BMI. This is also true of other similar studies (Higgs and Woodward, 2009;
556 Higgs and Donohoe 2011; Mittal et al. 2011; Brunstrom et al. 2011), although one
557 study has explored the effects of focused attention during eating in overweight women
558 and found similar effects (Robinson et al. 2014). Given the proposed underlying
559 cognitive mechanisms, it seems unlikely that different effects would be observed in a
560 more representative sample, but this should be confirmed in future studies. The effects
561 have also only been observed over a short time frame and so it would be interesting to

562 examine whether there are sustained effects of manipulating attention during eating on
563 cumulative intake over a longer period. In addition, the effects of manipulating
564 attention during eating on later consumption have only been investigated for snacking
565 and it would be interesting to know if later meals are similarly affected. Alternative
566 methods could also be used to provide convergent evidence on the role of attention
567 and memory in appetite control, for example by using ecological momentary
568 assessment to examine relationships between these variables and food intake in a
569 more naturalistic setting.

570

571 The fact that large effects sizes have been observed in these and other studies has
572 implications for theories of appetite control as well as potential practical applications.

573 The data provide further evidence for a role of memory for recent eating in appetite
574 control and emphasize the importance of higher cognitive function in eating behavior
575 (Higgs, 2015). There are also implications for understanding the relations between
576 diet and cognition. There is emerging evidence that Western-type diets can damage
577 brain structures important for learning and memory (Kanoski and Davidson, 2011).

578 These data, together with the evidence that food intake is influenced by processes that
579 recruit memory and attention, suggest that there are bidirectional links between
580 cognition and diet. Consumption of a high-fat, high-sugar diet may have detrimental
581 effects on memory function and appetite control which sets up a vicious cycle to
582 promote overeating (Francis and Stevenson 2011; Davidson et al. 2005). However,
583 the results also suggest that strategies aimed at promoting attentive eating and better
584 memory for recently eaten foods may be helpful in appetite control. The feasibility of
585 using a smartphone app to prompt recall of food consumed recently prior to the next
586 eating occasion was tested recently in a small trial of overweight participants

587 (Robinson et al. 2013). The results suggested that a randomized controlled trial testing
588 proof of principle for an attentive eating intervention on weight loss is warranted.
589 There are also implications of the present findings for understanding the effects of
590 different types of distractors on eating. Social eating situations are distracting
591 (Hetherington et al. 2006), which may contribute to the social facilitation of eating
592 (Herman, 2015), yet in these situations there are also food related cues present from
593 watching others eat. It would be interesting to assess the effects on meal memory and
594 later intake of social meals in which participants are consuming the same versus
595 different foods to their companions.

596

597 In summary, further evidence is provided of the role of attention to eating and
598 memory for recent eating in the control of food intake. The effect of distraction during
599 eating on later consumption is a large effect size that can be offset somewhat by the
600 presence of food-related cues during distraction. Focusing on food during eating can
601 reduce later consumption especially if the focus is on personal consumption. The
602 effects are moderate to large and replicable suggesting that they may provide a firm
603 evidence base for the development of interventions aimed at enhancing appetite
604 control.

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606

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688 Figure 1 – Mean biscuit intake according to condition across Studies 1-3. Error bars

689 are 95% confidence intervals.

690

691 Table 1. **Lunch items in presentation order for Study 1**

Type of food	Amount (g)	Energy per portion (kcal)
Salt and vinegar crisps	12	66
1/4 slice cheese and tomato sandwich	27	91
Mini sausage roll	16	58
Cherry tomatoes	40	8
1/4 slice Ham sandwich	35	38
Ready salted crisps	12	64
Mini Cornish pasty	24	66
Carrot batons	20	9
TOTAL	186	400

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694 Table 2: Lunch items in presentation order for Study 3

695	Type of food	Amount (g)	Energy per portion (kcal)
696	Salt and vinegar crisps	12	66
697	¼ slice cheese and tomato sandwich	27	91
698	Mini sausage roll	16	58
699	Cherry tomatoes	40	8
700	¼ slice ham sandwich	35	108
701	Carrot batons	20	9
702	Mini Cornish pasty	24	66
703	Ready salted hula hoops	12	64

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724 Table 3 characteristics of the sample for Study 1.

	Control	Low Distraction	High Distraction
Age (years)	20.31 (2.02)	19.77 (1.64)	19.85 (1.68)
BMI	22.64 (3.15)	21.38 (1.64)	21.70 (2.41)
Restraint (DEBQ 0.5)	2.75 (0.86)	2.57 (1.09)	2.72 (0.89)
Emotional eating (DEBQ 0-5)	3.42 (0.49)	3.46 (0.54)	3.33 (0.54)
External eating (DEBQ 0-5)	2.74 (1.26)	2.80 (0.86)	2.29 (0.95)
Hunger pre-lunch (0-100)	68.23 (12.26)	66.23 (16.22)	50.82 (1.44)
Hunger pre-snack (0-100)	30.85 (21.79)	30.15 (16.68)	30.51 (1.98)

725

726 Table 4: characteristics of the sample for Study 2.

Measure (SD)	Control	Food TV	TV
Age (years)	20.6 (4.2)	18.6 (0.8)	19.9 (4.2)

BMI	22.9 (3.0)	21 (2.6)	22.6 (4.2)
Restraint (DEBQ 0.5)	2.6 (1.0)	2.5 (1.0)	2.5 (1.0)
Disinhibition (TFEQ 0-16)	9 (2.5)	7.9 (2.0)	9 (2.1)
Hunger pre-lunch (0-100)	59.7 (21.1)	58.9 (18.1)	62.5 (14.4)
Hunger pre-snack (0-100)	47.6 (27.8)	55.3 (15.8)	50 (17.8)

727

728 Table 5 characteristics of the sample for Study 3.

729

Measure (SD)	Control	Celebrity imagining	Self-imagining
Sex	Female (12) male (3)	Female (14) male (1)	Female (12) male (3)
Age (years)	19.3 (1.3)	19.1 (0.6)	18.9 (0.8)
BMI	22.6 (4.4)	22.6 (2)	20.9 (2.4)
Restraint (DEBQ 0.5)	1.9 (0.7)	2.0 (0.6)	2.2 (1)
Emotional eating (DEBQ 0-5)	3.2 (0.5)	3.0 (0.4)	3.3 (0.6)
External eating (DEBQ 0-5)	2.7 (0.9)	2.0 (0.8)	2.6 (1)

Hunger pre-lunch (0-100)	68.1 (5)	68.9 (16.9)	64.3 (21)
Hunger pre-snack (0-100)	46.5 (22)	36.9 (16)	34.5 (22.8)

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