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### Article

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1 The effect of acute alcohol consumption on meal memory and subsequent food intake: Two  
2 laboratory experiments

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### Abstract

14 Altering the quality of episodic meal memories has been shown to affect subsequent food intake.  
15 Acute alcohol consumption disrupts memory formation and produces short-term overeating. In two  
16 studies, we investigated whether alcohol consumption can affect meal-related memories and later  
17 food intake. Study 1 (N = 60, 50% male) investigated how consumption of an alcoholic drink (0.5  
18 g/kg) prior to consumption of a lunch meal affected meal memory of that lunch, and later food  
19 intake, compared with a placebo-alcohol. Findings revealed that alcohol consumption did not impair  
20 meal memory, and did not affect subsequent food intake. Study 2 (N = 72, 50% male) investigated  
21 whether, due to alcohol's retrograde facilitation effect (the enhancement of recall due to reduced  
22 interference at the point of exposure) consuming alcohol *after* consumption of a lunch meal could  
23 enhance meal memory, compared with when consumed before a lunch meal (both a dosage of 0.6

24 g/kg), and compared with consumption of a soft drink. Contrary to prediction, alcohol consumed  
25 after a lunch meal did not significantly increase meal memory. But, certain types of meal memory  
26 were impaired when alcohol was consumed before the meal, compared with consumption of a soft  
27 drink. Subsequent food intake did not differ between conditions. Taken together, findings suggest  
28 that alcohol intoxication can impair some forms of meal memory recall, likely due to disruption of  
29 memory formation during the encoding phase. However, there was no evidence that this  
30 impairment contributes towards alcohol-induced overeating.

31 Keywords: alcohol; episodic memory; appetite; food intake

32 List of abbreviations: AUDIT (Alcohol Use Disorders Identification Test), BAES (Biphasic Alcohol  
33 Effects Scales), BMI (body mass index), BrAC (breath alcohol concentration), DEBQ (Dutch Eating  
34 Behaviour Questionnaire), IAPS (International Affective Picture System), TLFB (Timeline Follow-back).

## 35 **1. Introduction**

36 A multitude of cognitive processes have been identified as factors which influence eating behaviour  
37 (Higgs & Spetter, 2018). Such factors include attention and memory for recent eating in determining  
38 food intake. A growing body of research has demonstrated that impairments to episodic memories  
39 relating to recently consumed food can alter subsequent food intake. For example, animal research  
40 has demonstrated that lesions to the hippocampal region results in hyperphagia and weight gain  
41 (Clifton, Vickers, & Somerville, 1998; Davidson, Kanoski, Walls, & Jarrard, 2005). More recently, an  
42 animal study by Hannapel et al. (2019) revealed that inhibition of glutamatergic neurons to dorsal  
43 and ventral hippocampal areas after consumption of a meal, leads to an increase in the amount of  
44 food consumed during a subsequent meal. Further, evidence from amnesic patients has  
45 demonstrated that individuals who have an impaired ability of reporting memories for recent eating  
46 also display evidence of overeating (Higgs, Williamson, Rotshtein, & Humphreys, 2008).

47 Notably, manipulating the quality of episodic meal-related memories also affects subsequent food  
48 intake. This has been investigated by either enhancing or impairing the quality of a meal memory.  
49 Research has shown that cueing memory for a recently consumed meal (i.e., lunch consumed that  
50 day) reduces subsequent food intake, relative to no cue and when cued of a lunch meal consumed  
51 the previous day (Higgs, 2002; Higgs, Williamson, & Attwood, 2008), suggesting that cueing of only  
52 very recent eating affects subsequent food intake. Similarly, many studies have investigated the  
53 effect of enhancing the level of attention placed towards a meal (specifically relating to the sensory  
54 properties of the food) on subsequent food intake, which has been suggested to increase meal  
55 memory. Findings are mixed, with some experiments showing that this increase in focused attention  
56 leads to a reduction in later food intake in both samples exclusively of women (Higgs & Donohoe,  
57 2011; Robinson, Kersbergen, & Higgs, 2014) and a mixed gender sample (Seguias & Tapper, 2018).  
58 Other studies, however, have failed to show this same reduction in a mixed sex (Whitelock et al.,  
59 2018), a male-only sample (Whitelock et al., 2019) and most recently a female-only sample (Tapper  
60 & Seguias, 2020).

61 Other research has focused on the effect of impairing memories of a recently consumed meal on  
62 subsequent food intake. This has been investigated by taking attention away from a meal whilst  
63 eating by using distractors such as television viewing (Higgs & Woodward, 2009; Mittal, Stevenson,  
64 Oaten, & Miller, 2011) and playing computer games (Oldham-Cooper, Hardman, Nicoll, Rogers, &  
65 Brunstrom, 2010). These studies have demonstrated that distracted participants display poorer  
66 levels of recall for meal memory, and greater subsequent food intake, compared with participants  
67 who eat in the absence of a distractor. This impairment of episodic meal memory is argued to be due  
68 to disruption during the encoding phase of memory formation.

69 Acute consumption of alcohol has also been shown to impair processes of episodic memory,  
70 resulting in impaired delayed recall of stimuli when exposure or learning occurs shortly after alcohol  
71 consumption (Hashtroudi et al., 1984; Nilsson, Bäckman, & Karlsson, 1989; Söderlund, Parker,

72 Schwartz, & Tulving, 2005). This is believed to occur due to alcohol-induced disruptions to activity in  
73 the CA1 region of the hippocampus (White, Matthews & Best, 2000; Zola-Morgan, Squire, & Amaral,  
74 1986). To date, no studies have investigated how acute alcohol consumption can impair recall of  
75 recently consumed food.

76 Acute alcohol consumption has also been shown to increase short-term levels of food intake,  
77 relative to consumption of alcohol-free drinks (Caton, Ball, Ahern, & Hetherington, 2004; Caton,  
78 Marks, & Hetherington, 2005; Kwok et al., 2019; Yeomans, 2010). Several mechanisms are likely to  
79 contribute to alcohol's effect on increased intake, such as impairment of inhibitory control  
80 (Christiansen, Rose, Randall-Smith, & Hardman, 2016) and enhancing the reward value of certain  
81 foods (Schrieks et al., 2015). Furthermore, biological factors are also likely to contribute towards  
82 elevated levels of food intake, as acute alcohol consumption produces hyperactivity of agouti-  
83 related protein neurons (Cains et al., 2017) and produces inhibition of leptin and GLP-1 hormones  
84 (Raben et al., 2003; Röjdmark et al., 2001). A currently unexplored, but potentially important  
85 mechanism of this increased food intake may come from disruptions to meal memory if an alcoholic  
86 drink is consumed before consumption of food.

## 87 2. Study 1

### 88 Overview

89 In Study 1, participants either 1) consumed a pre-load meal after consuming an alcoholic drink, or 2)  
90 consumed a pre-load meal, after consuming a placebo-alcohol drink. After a delay of 30 minutes, all  
91 participants were given *ad libitum* access to chocolate chip cookies and recalled details of the pre-  
92 load meal. We hypothesised that participants who consumed an alcoholic drink would show greater  
93 impairment of meal memory and greater *ad libitum* food intake, compared with participants who  
94 consumed an alcohol-free placebo.

## 95 **2.1 Method**

### 96 2.1.1 Participants

97 Sample size was determined from previous investigations examining the effect of distraction on  
98 meal memory and subsequent food intake. Oldham-Cooper and colleagues (2010) found an effect  
99 size of  $d = 0.68$  for the comparison between undistracted and distracted individuals on food intake  
100 and an effect size of  $d = 0.67$  for meal memory between these two conditions. In order to detect an  
101 effect size of  $d = 0.67$  with 80% power at an alpha level of 5%, 58 participants were required. 60  
102 participants were recruited to allow for any cases which may need to be excluded. 60 participants  
103 (male = 30) aged between 18 and 62 y ( $M = 24.5$ ,  $SD = 10.1$ ) took part, and were recruited through  
104 online and email advertisement, and word-of-mouth. Participants were eligible to take part if they  
105 had no history of food allergies or intolerances, were not vegetarian or vegan, and were regular  
106 consumers of alcohol (consuming at least 10 UK alcohol units per week - one UK unit = 8 g of  
107 alcohol). Participants were excluded if they had a current or past alcohol use or eating disorder, had  
108 a current or recent illness that may increase sensitivity to alcohol (e.g., cold and flu), were taking  
109 medication that may be affected by alcohol, and were currently breastfeeding or pregnant. All  
110 participants provided written informed consent to participate in the experiment, which was  
111 approved by the University of Liverpool Health and Life Sciences Research Ethics Committee.  
112 Participants were reimbursed through either course credits or received a £10 shopping voucher.

### 113 2.1.2. Design

114 The study used a between-subjects, single-blind randomised design with drink type (alcoholic drink,  
115 placebo-alcohol) as an independent variable. The dependent variables were free recall and serial  
116 recall of the lunch meal, general memory recall, *ad libitum* intake (kcal) and total intake (test drink  
117 and *ad libitum* kcal combined).

### 118 2.1.3. Measures

119 *Beverage Preparation and Administration.* The present study used an alcohol dosage of 0.5 grams of  
 120 alcohol per kilogram of participant bodyweight (g/kg) (35.76 grams of alcohol for a participant  
 121 weighing 70 kg). The alcoholic drink contained vodka (Smirnoff Red, 37.5% ABV) up to a maximum of  
 122 200 ml of vodka (1 g of vodka = 2.08 kcal) and was mixed with chilled diet lemonade in the ratio one-  
 123 part vodka to three parts diet lemonade. The placebo drink consisted of diet lemonade only; a vodka  
 124 mist was sprayed on the surface of the drink to create the impression that it contained alcohol.

125 *Lunch meal.*

126 The lunch meal used was similar to that used in a previous study (Oldham-Cooper et al., 2010). All  
 127 lunch items were manufactured by Tesco's Ltd except for the potato chip snack (Hula Hoops; KP  
 128 Snacks Ltd, Ashby-de-la-Zouch, United Kingdom). Nine foods were served one-by-one on separate  
 129 plates in 90-second intervals. The foods were served in this way in order to match eating duration  
 130 across foods and participants, and to measure how well participants remembered the order of the  
 131 nine foods.

132 Table 1. Lunch items served, in presentation order.

<b>Food Item</b>	<b>Amount (grams)</b>	<b>Energy per portion (kcal)</b>
Cheese twists	8	41
Ham sandwich <sup>a</sup>	35	94
Carrot batons	25	11
Mini Cornish pasty	30	104
Cheese sandwich <sup>b</sup>	35	125
Sausage Roll	11	34
8 Cherry tomatoes	71	14
Scotch egg	12	28
15 Potato chip snacks	13	64
Total	239	515

133 <sup>a</sup> Comprising half a slice of Tesco White Medium Bread (20 g), 5 g of Tesco Butterpak Spreadable  
 134 Butter, 10 g of Tesco Everyday Value Cooked Ham.

135 <sup>b</sup> Comprising half a slice of Tesco White Medium Bread (20 g), 5 g of Tesco Butterpak Spreadable  
 136 Butter, 10 g of Tesco Everyday Value Grated Cheddar.

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138 *Taste Test Preparation.* The test meal consisted of a 200 g serving of Maryland chocolate chip  
139 cookies (487 kcal/100g). The test meal was also served with a 250 g serving of water. Cookies were  
140 broken into smaller pieces so that participant could not easily monitor the amount consumed (Higgs  
141 & Woodward, 2009).

142 *Free recall task:* Participants were required to recall the nine food items they consumed during the  
143 lunch meal in no specific order. Using pen and paper, participants wrote down as many of the lunch  
144 items as they could remember. A list of accepted answers are included in the supplementary  
145 materials (Table S3). Two independent reviewers rated whether participants correctly recalled each  
146 of the nine lunch items, with an agreement of 94.45%. Disagreements in scoring was resolved by the  
147 lead author.

148 *Serial order recall task:* Participants were asked to recall the specific order in which the nine food  
149 items were presented.

150 *Meal vividness rating:* Participants were asked on a 100 mm VAS 'How vividly can you remember the  
151 lunch meal you ate earlier?' Anchored scores were 'Not At All' and 'Extremely'.

152 *General Memory Measure:* General memory performance was also measured. Participants were  
153 shown a wordlist consisting of 6 capital cities and 6 countries to memorise.

154 *Dutch Eating Behavior Questionnaire.* The Dutch Eating Behaviour Questionnaire (DEBQ; van Strien,  
155 Frijters, Bergers, & Defares, 1986) is a 33-item questionnaire which measured eating styles  
156 associated with being overweight. The three subscales are restraint ( $\omega = .93$ ), emotional eating ( $\omega$   
157 = .96), and external eating ( $\omega = .90$ ).

158 *Timeline Follow Back.* In the Timeline Follow Back (TLFB; Sobell & Sobell, 1992), participants  
159 estimated the number of alcohol units consumed over the past 7 days, measuring typical drinking  
160 habits.



161 *Alcohol Use Disorders Identification Test.* The Alcohol Use Disorders Identification Test (AUDIT;  
162 Saunders, Aasland, Babor, de la Fuente, & Grant, 1993) is a 10-item questionnaire assessing  
163 hazardous drinking. Scores range between 0 and 40, with scores of  $\geq 8$  indicating hazardous alcohol  
164 use ( $\omega t = .84$ ).

165 *Snack Urge Scale.* The Snack Urge Scale (SUS; Hardman et al., 2015) comprises four items which  
166 measured expected liking, desire to consume, craving, and difficulty to resist chocolate chip cookies.  
167 Each item was measured using a 100 mm VAS ('Not at all' – 'Extremely') and combined as a total  
168 snack urge score (maximum score of 400).

169 *Appetite Ratings.* (AR; Blundell et al., 2010) of hunger (I feel hungry) and fullness (My stomach feels  
170 full) were measured using a 100 mm VAS ('Not at all' – 'Extremely'). These scores were combined  
171 (hunger added to the inverse score of fullness) and reported as a single appetite rating (maximum  
172 score of 200).

173 *Biphasic Alcohol Effects Scale.* (BAES; Martin et al., 1993). The BAES is a 14-item scale which is  
174 comprised of two 7- item sub-scales, measuring the sedative and stimulating effects of alcohol,  
175 respectively. Participants were required to rate the extent to which they are experiencing both  
176 sedative (e.g., down, inactive) and stimulatory feelings (e.g., elated, energized) at the present  
177 moment on a 10-point scale, anchored scores are 'Not at all' and 'Extremely'.

#### 178 2.1.4. Procedure

179 Test sessions took place between 12:00 – 18:00 on weekdays in the Department of Psychology on  
180 the University of Liverpool campus. Sessions lasted approximately 120 minutes. The study was  
181 advertised as a study investigating 'alcohol's effect on memory and taste perception'. Participants  
182 were told that memory performance would be measured but were not told that memory of the  
183 lunch meal would be assessed. Prior to the beginning of the session, all participants were asked to  
184 consume a light meal not high in fat approximately an hour before the beginning of the test session.

185 Upon arrival, participants were presented with the information sheet and provided informed  
186 consent. Participants were asked to report when they had last eaten and what they had consumed,  
187 before being breathalysed (all had a BrAC of 0.00). Participants then completed a medical history  
188 questionnaire to assess whether they had any food allergies. Height and weight measurements were  
189 taken in order to calculate the alcohol dosage. Next, baseline appetite ratings and snack urge scale  
190 ratings were recorded, followed by completion of the DEBQ, AUDIT, TLFB and baseline BAES.  
191 Participants then consumed the test drink. They were required to consume the drink within 10  
192 minutes, followed by a 10-minute absorption period where participants sat quietly. Next, a second  
193 breathalyser measure was taken, followed by a second set of BAES, appetite and snack urge ratings.  
194 Next, participants consumed their lunch meal. Afterwards, participants completed a third set of  
195 appetite, snack urge and BAES ratings. Participants were then presented with the word list for the  
196 general memory measure to memorise for one minute. This was measured in order to observe  
197 whether alcohol consumption successfully impaired general memory performance, as would be  
198 expected. Afterwards, participants took a 30-minute break during which, they were required to stay  
199 in the test room and to abstain from eating. Participants were offered light reading material during  
200 this time. After the break, participants were given one minute to recall items from the word list,  
201 before completing another breathalyser measure and appetite and snack urge ratings. Participants  
202 then completed the taste test for 10 minutes. During this period, participants were asked to taste  
203 the test food as much or as little as they wanted, and to provide ratings based on certain  
204 characteristics of the foods (data was not analysed). Afterwards, BAES ratings were taken again  
205 followed by a final breathalyser measure (see Table S2 of the supplementary materials for BrAc  
206 scores across both conditions). Participants were then given three minutes to complete the free  
207 recall lunch item task, followed by three minutes to complete the serial order recall task. The lunch  
208 memory measures were completed after the taste test to avoid cueing participants of their lunch  
209 meal. Participants then completed the vividness rating, and an awareness check. Finally, participants  
210 were fully debriefed and reimbursed for their time.

211 Table 2. Overview of the procedure. With approximate timings and durations of each task

Task/Measure	Start Time (Minutes Post-arrival)	Duration (in minutes)
Information Sheet	0	1
Consent Form	1	2
Baseline breathalyser measure	3	1
Medical History Questionnaire	4	3
Height and Weight Measurement	7	2
Baseline Appetite Ratings	9	0.5
First Snack Urge Questionnaire	9.5	0.5
Dutch Eating Behaviour Questionnaire	10	3
Alcohol Use Disorders Identification Test	13	1
Timeline Follow-back Questionnaire	14	2
Baseline BAES	16	1
Consumption of Drink	17	10
Absorption Period	27	10
Second Breathalyser Measure	37	1
Lunch Meal	38	13.5
Post-lunch Appetite Ratings	51.5	0.5
Second Snack Urge Questionnaire	52	0.5
Second BAES	52.5	1
Memorise Word List	53.5	1
Break	54.5	30
Word List Recall	84.5	1
Third Breathalyser Measure	85.5	1
Third Hunger, Fullness, & Thirst Ratings	86.5	0.5
Third Snack Urge Questionnaire	87	1
Third BAES	88	1
Taste Test	89	10
Fourth BAES	99	1
Fourth Breathalyser Measure	100	1
Free Recall Task	101	3
Serial Recall Task	104	3
Vividness Rating	107	0.5
Awareness Check	107.5	2
Debrief Sheet	109.5	2
Reimbursement	111.5	2

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214 2.1.5. Data Analysis

215 Analysis was performed using SPSS 25 (IBM Corporation, Armonk, NY, USA). We performed

216 independent t-tests to test for any significant differences between conditions in the meal memory

217 measures, general memory measure, food calorie intake and total calorie intake (cookie and drink  
 218 calories combined). Mixed ANOVAs were conducted to observe differences between drink  
 219 conditions and differences across time for appetite ratings, snack urge ratings and BAES stimulation  
 220 and sedation ratings (see findings of snack urge ratings and BAES ratings in the supplementary  
 221 materials). Four participants did not consume all of the lunch meal. A sensitivity analysis revealed  
 222 that removing these participants from all analyses did not affect the statistical significance of the  
 223 results. The method and analysis strategy for Study 1 was pre-registered on the Open Science  
 224 Framework (see protocol here: [osf.io/mbxs8/](https://osf.io/mbxs8/)).

225 **2.2. Results**

226 2.2.1. Participant characteristics

227 Means and standard deviations are displayed in Table 3.

228 Table 3. Sample characteristics and baseline scores, split by drink condition (mean ± SD)

	Alcoholic drink (N = 30)	Placebo-Alcohol (N = 30)
Age (y)	23 ± 9.7	25.9 ± 10.5
AUDIT (out of 40)	10.8 ± 5	11 ± 5.4
BMI (kg/m <sup>2</sup> )	23.6 ± 3.8	25.8 ± 5.3
DEBQ Emotional	2.4 ± 0.9	2.5 ± 0.7
DEBQ External	3.4 ± 0.6	3.3 ± 0.7
DEBQ Restraint	2.4 ± 0.9	2.3 ± 0.7
7-day TLFB (alcohol units)	17 ± 12	16 ± 11
Baseline Appetite (out of 200)	84 ± 42	73 ± 37
Baseline Snack Urge (out of 400)	205 ± 83	177 ± 64
Baseline Sedation BAES (out of 49)	18 ± 11	16 ± 12
Baseline Stimulation BAES (out of 49)	33 ± 11	34 ± 8

229 AUDIT = Alcohol Use Disorders Identification Test; BMI = Body Mass Index; DEBQ = Dutch Eating  
 230 Behaviour Questionnaire; TLFB = Timeline Follow-back; BAES = Biphasic alcohol effects scale.

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237 2.2.2 Memory Measures (Table 4)

238 Table 4. Scores on outcome measures, split by drink condition (mean  $\pm$  SD)

	Alcoholic Drink	Placebo-Alcohol
Vividness Rating (out of 100)	72 $\pm$ 15	73 $\pm$ 12
General Memory Recall (out of 12)	7.3 $\pm$ 2.1	8.2 $\pm$ 1.9
Lunch Item Recall (out of 9)	7.4 $\pm$ 1.6	8.1 $\pm$ 1.4
Serial Order Recall (out of 9)	4.6 $\pm$ 2.2	5.1 $\pm$ 2.3
Cookie intake (kcal)	285 $\pm$ 205	219 $\pm$ 186
Total intake (drink and cookies combined; kcal)	514 $\pm$ 218*	224 $\pm$ 186*

239 \* $p < .05$

240 There was no significant difference between drink conditions for vividness ratings  $t(58) = .34, p =$   
241  $.735, d = 0.09$ , general memory recall  $t(58) = 1.68, p = .098, d = 0.43$ , for serial-order recall  $t(58) =$   
242  $0.92, p = .362, d = 0.24$ , or for the free-recall lunch item task  $t(58) = 1.66, p = .103, d = 0.43$ .

243 2.2.3. Calorie Measures (Figure 1)

244 There was no significant difference between drink conditions on the amount of calories consumed  
245 during the taste test  $t(58) = 1.31, p = .196, d = 0.34$ . However participants in the alcohol drink  
246 condition consumed significantly more calories than the placebo-alcohol condition when combining  
247 calories from both the drink and cookies consumed  $t(58) = 5.55, p < .001, d = 1.43$ .

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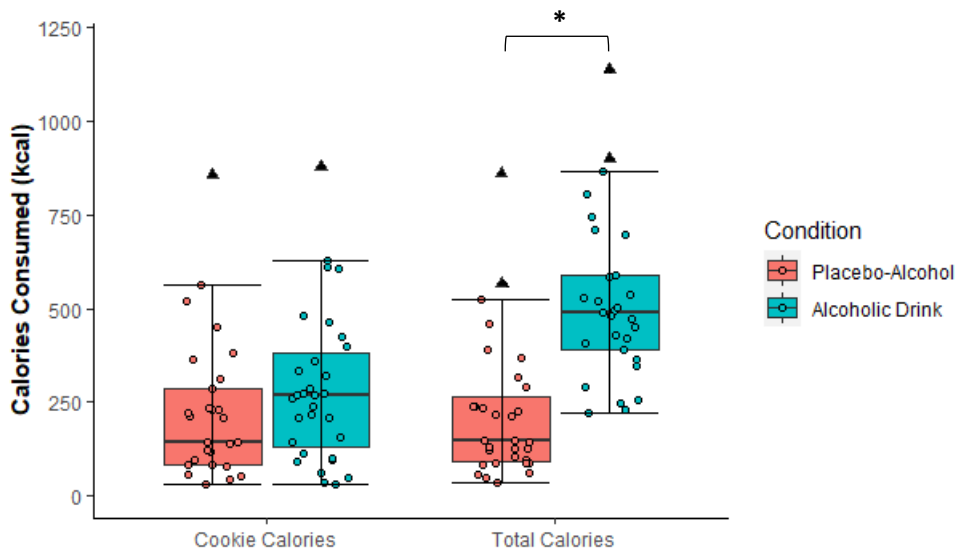


Figure 1. Boxplot displaying individual data points for number of calories consumed during the *ad libitum* taste test (cookie calories) and combined with calories consumed from the test drink (total calories), split by condition. \* $p < .001$ . Triangles represent outliers.

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#### 269 2.2.4. Appetite Ratings

270 A 2 (drink; placebo-alcohol, alcoholic drink) x 4 (time; baseline, post-drink, post-lunch, pre-taste test)

271 mixed ANOVA was conducted with drink as a between-subjects factor and time as a within-subjects.

272 Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of

273 time  $\chi^2(5) = 23.25, p < .001$ , Greenhouse-Geisser corrected tests are reported ( $\epsilon = .828$ ). The analysis

274 revealed a significant main effect of time  $F(2.48, 141.62) = 78.83, p < .001, \eta_p^2 = .58$ . Bonferroni

275 pairwise comparisons revealed that baseline appetite ratings were significantly higher than post-

276 lunch ( $p < .001$ ; mean difference = 51; 95% CI [37, 66]) and pre-taste test ratings ( $p < .001$ ; mean

277 difference = 39; 95% CI [28, 51]). Post-drink ratings were also significantly higher than post-lunch ( $p$

278  $< .001$ ; mean difference = 63; 95% CI [49, 78]) and pre-taste test ratings ( $p < .001$ ; mean difference =

279 51; 95% CI [36, 66]). Post-lunch ratings were shown to be significantly lower than pre-taste test

280 ratings ( $p = .006$ ; mean difference = 12; 95% CI [-21, -3]). The analysis also revealed a nonsignificant

281 main effect of drink type  $F(1, 57) = 2.67, p = .108, \eta_p^2 = .05$  and a nonsignificant drink type x time

282 interaction  $F(3, 171) = .78, p = .504, \eta_p^2 = .01$ . See supplementary materials for full list of means and  
283 standard deviations of appetite ratings at each time point, split by condition.

### 284 **2.3. Interim discussion**

285 Study 1 found that consumption of an alcoholic drink did not significantly affect performance on the  
286 free-recall food memory task, serial-recall task or ratings of meal vividness, compared with those  
287 who consumed the placebo-alcohol. Therefore, our prediction that alcohol consumption can impair  
288 meal memory is rejected. Findings also revealed that consumption of the alcoholic drink did not  
289 significantly decrease performance on the general memory task, nor did it significantly alter *ad*  
290 *libitum* consumption of cookies. This goes against our prediction that alcohol consumption would  
291 decrease general recall and increase food intake.

292 One explanation for failing to find a significant difference in all memory measures may have been  
293 due to the alcohol dosage used. Previous studies investigating the effect of alcohol intoxication on  
294 delayed recall typically use higher doses than the one used in the present experiment (1 ml/kg -  
295 Söderlund et al., 2005; 0.66 ml/kg - Sutker et al., 1983). This is important because research has  
296 shown that memory impairment can occur in a dose-dependent manner (Bisby, Leitz, Morgan, &  
297 Curran, 2010). Furthermore, by minimising alcohol expectancy effects between the two conditions  
298 by using an alcohol-free placebo, the difference in recall may have been smaller than in a more  
299 naturalistic context where individuals are aware when a drink contains zero alcohol. However,  
300 previous research suggests alcohol expectancy has a small effect on information processing (Hull &  
301 Bond, 1986).

302 It is plausible that the aspects of meal memory measured in Study 1 may not be relevant to  
303 subsequent food intake. Other studies have used measures which focus on recalling the quantity of a  
304 lunch meal (Mittal et al. 2011; Whitelock et al., 2018; Whitelock et al., 2019) and recalling feelings  
305 relating to interoceptive states, such as hunger (Brunstrom et al., 2012; Whitelock et al., 2018;

306 Whitelock et al., 2019). These may be more important and relevant components of meal memory  
307 which help guide subsequent eating episodes, as compared with the current measures used.

308 Study 1 has a few limitations. Firstly, participants in the alcohol condition completed the recall  
309 measures when they were still intoxicated (BrAc > 0, see Table S2 of the supplementary materials for  
310 BrAc ratings across both conditions). It is therefore not possible to confirm whether impairments of  
311 memory performance were the result of disruption during the encoding or the retrieval phase, this  
312 limitation could be overcome by incorporating a longer delay between alcohol consumption and  
313 subsequent recall. Furthermore, the present study was not able to isolate the effect of impaired  
314 memory on subsequent food intake. Alcohol intoxication influences many factors which can increase  
315 food consumption, such as inhibitory control (Christiansen et al., 2016) and reward processing  
316 (Schrieks et al., 2015). As participants were still intoxicated during the taste test, the two conditions  
317 were unmatched on a number of confounding factors. Given these issues, Study 2 looked to build  
318 upon the current findings and to address the mentioned limitations.

319

320

### 3. Study 2

321 Overview

322 Study 2 investigated whether other forms of meal memory may be disrupted by alcohol intoxication  
323 and alter later food intake. We chose to measure participants' visual memory of the portion size of a  
324 meal consumed, vividness of a meal and memory of satiety experienced after a meal. Furthermore,  
325 we used a greater alcohol dosage - 0.6 g/kg - and told participants in the alcohol-free condition that  
326 they would be consuming a soft drink. This was done to produce a clearer measure of alcohol's  
327 effect (combining both pharmacological and expectancy effects) on delayed recall. We also  
328 incorporated a longer interval between consumption of the test drink and subsequent recall in order  
329 to allow for participants to have a lower alcohol level at the point of recall.



330 An additional aim was to investigate whether alcohol consumed *after* a lunch meal may in fact  
331 *enhance* meal memory. The ability for alcohol to influence episodic memories may depend on  
332 whether information is presented before or after consuming alcohol. As previously mentioned,  
333 research has shown that alcohol impairs learning when intoxication occurs at the encoding stage  
334 (when alcohol is consumed before information is presented). However, alcohol can *enhance* learning  
335 when intoxication occurs *after* the encoding stage and during consolidation (when alcohol is  
336 consumed after information is presented; Knowles & Duka, 2004; Parker et al., 1980; Weafer, Gallo,  
337 & De Wit, 2016). For example, Weafer, Gallo and De Wit (2016) found that alcohol consumed after  
338 presentation of stimuli significantly improved recall compared with consumption of a placebo-  
339 alcohol, suggesting that alcohol consumption can aid consolidation of recent memories and boost  
340 later recall. This phenomenon, termed ‘retrograde facilitation’ is believed to occur due to the ability  
341 of alcohol intoxication to protect memories formed prior to alcohol consumption by impairing the  
342 ability to form new memories, and therefore reduce interference once alcohol has been consumed  
343 (Wixted, 2005). Alcohol consumed after a meal may therefore increase the quality of episodic  
344 memories relating to the meal, compared with when alcohol is consumed before the meal, and  
345 when alcohol is not consumed.

346 To investigate the effect of the timing of the alcoholic drink in relation to the meal, participants  
347 completed two sessions. In session one, all participants consumed a soft drink followed by a lunch  
348 meal. After a break, participants were given *ad libitum* access to chocolate chip cookies and  
349 completed a general memory task – these two tasks were used as baseline measures of food intake  
350 and general memory recall. This session was included in order to 1) provide a baseline score of food  
351 intake which was needed for the data analysis (see section 3.1.5), as this allowed us to control for  
352 between-subject variance of food intake when measuring differences in food intake between  
353 conditions, as has been done in previous research (e.g., Gadah, Brunstrom, & Rogers, 2016), and 2)  
354 to record baseline general memory performance in case differences between conditions may exist.  
355 In session two, participants were assigned to one of three conditions and either 1) consumed an

356 alcohol-free drink before consuming a lunch meal (soft drink condition), 2) consumed an alcoholic  
357 drink before consuming a lunch meal (pre-meal drink condition), or 3) consumed an alcoholic drink  
358 after consuming a lunch meal (post-meal drink condition). After a break (2 hours long in the post-  
359 meal drink condition, 2.5 hours long in the soft-drink and pre-meal drink condition), participants  
360 were given *ad libitum* access to chocolate chip cookies and meal memory recall was measured. We  
361 predicted that meal memory would be greatest in condition three (i.e. post-meal drink  
362 condition) and lowest in condition two (pre-meal drink condition), and therefore we also predicted  
363 that *ad libitum* food intake would be lowest in condition three and greatest in condition two. We  
364 also tested for general memory performance of words and predicted that recall of words presented  
365 before the test drink would be greater in the two alcohol conditions as compared with the soft drink  
366 condition. Conversely, we predicted that recall of words presented after the test drink would be  
367 greater in the soft drink condition, compared with the two alcohol conditions.

### 368 3.1 Method

#### 369 3.1.1 Participants

370 Sample size was calculated based from previous research examining the enhanced effect on memory  
371 consolidation after alcohol consumption. A previous study found that alcohol consumption after  
372 viewing neutral stimuli during consolidation produced a large effect on memory recall (Weafer, Gallo  
373 & De Wit, 2016;  $d = 0.79$ ). In order to detect a comparable effect with 80% power,  $\alpha = 0.05$ , 66  
374 participants were required. We aimed to recruit 72 participants which would allow us to detect a  
375 large effect size ( $d = 0.76$ ) at 80% power,  $\alpha = 0.05$ . To power for food intake, the design controlled  
376 for between-subject differences in food intake by incorporating a baseline session, whereby *ad*  
377 *libitum* food intake was measured and included as a covariate when comparing differences in food  
378 intake. This analysis strategy has been used in previous research (e.g., Gadah, Brunstrom, & Rogers,  
379 2016) and was used in the present study in order to reduce the between-subjects variance of food  
380 intake without implementing a within-subjects design. This is because the implementation of a

381 within-subjects design would likely produce order effects relating to the meal memory recall  
382 measures. With 72 participants, we were powered to detect an effect size of  $d = 0.5$  for differences  
383 in food intake at 80% power,  $\alpha = 0.05$ . In total, 73 participants were recruited due to one participant  
384 failing to attend the second session. After excluding this participant, 72 (male = 36) participants aged  
385 between 18 and 60 y ( $M = 24.31$ ,  $SD = 9.51$ ) were included in all data analyses. Participants were  
386 recruited through online and email advertisement, and word-of-mouth. The inclusion criteria were  
387 the same as in Study 1, except participants were required to typically consume at least 15 UK alcohol  
388 units per week. This was increased due to the larger alcohol dosage implemented in Study 2. All  
389 participants provided written informed consent to participate in the experiment, which was  
390 approved by the University of Liverpool Health and Life Sciences Research Ethics Committee.  
391 Participants were reimbursed through either course credits or a £20 shopping voucher.

### 392 3.1.2. Design

393 The study used a between-subjects, single-blind randomised design with drink type (soft drink, pre-  
394 meal drink, and post-meal drink) as an independent variable. All participants attended two sessions.  
395 In the first (baseline) session, participants completed the same procedure and consumed a soft  
396 drink, followed by a lunch meal and then an *ad libitum* taste test. A week later, participants then  
397 completed the procedure in their randomly assigned condition. The dependent variables in session 2  
398 were the number of calories consumed during the *ad libitum* taste test, total calories consumed  
399 (taste test calories and drink calories combined), meal vividness rating, memory for satiety, visual  
400 memory of the portion size of the lunch meal, and general memory recall.

### 401 3.1.3. Measures

402 *Beverage Preparation and Administration.* The present study used an alcohol dosage of 0.6 g/kg  
403 (42.96 grams of alcohol for a participant weighing 70 kg). The alcoholic drink contained vodka  
404 (Smirnoff Red, 37.5% ABV) up to a maximum of 200 ml of vodka (1 g of vodka = 2.08 kcal). The drink  
405 was mixed with chilled diet lemonade in the ratio one-part vodka to three parts diet lemonade. The

406 soft drink consisted of diet lemonade only, and the volume was matched for body weight such that  
407 participants weighing the same would consume the same total volume of liquid in either condition.  
408 All participants were told that they were consuming an alcohol-free diet lemonade drink during the  
409 first session, as were participants who were in the soft drink condition in session two.

410 *Lunchtime meal.*

411 Due to a manufactory change in the caloric content of the lunch meal partway through the study, 13  
412 participants consumed a lunch meal consisting of a 262.39 g serving of cheese and tomato pasta  
413 salad (Tesco UK). The remaining 59 participants consumed a 250.93 g serving of the same Tesco  
414 brand cheese and tomato pasta salad to ensure that all lunches were matched on caloric content  
415 (1.79 kcal per gram; 450 kcal per serving). The lunch meal was divided into six equicaloric portions,  
416 served one at a time in 90-second intervals to control for meal duration. A 250 g serving of water  
417 was provided with the lunch meal. The same lunch meal was served in both session 1 and 2.

418 *Taste Test Preparation:* The same as in Study 1.

419 *Meal vividness rating (Session 2):* The same as in Study 1.

420 *Picture presentations (Sessions 1 and 2):* To bolster the cover story and to measure general memory  
421 performance, participants were required to provide visual ratings of different images in both  
422 sessions 1 and 2. Participants were exposed to one set of images in session 1, and two sets in session  
423 2 (one before consumption of the test drink and one after). Pictorial stimuli were taken from the  
424 International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1997). Images across the  
425 three picture sets consisted of objects, animals and people. Each presentation consisted of 24  
426 images, each presented with a text label below which provided a name of the image (e.g., an image  
427 of an astronaut would have the text label 'Astronaut' displayed below it). All three presentations  
428 were matched on valence and arousal ratings (scored out of 9): session 1 picture set: valence = 5.91;  
429 arousal = 3.95, session 2 picture set A: valence = 5.99; arousal = 3.71, session 2 picture set B: valence

430 = 5.95; arousal = 3.89. The order of picture sets in session 2 were counterbalanced. For each  
431 presentation, images were presented alone with the text label for 5 seconds. Afterwards, the image  
432 and text label were presented on the left hand-side of the screen, and three rating scales on the  
433 right-hand side, this stayed on screen for 15 seconds. Participants were asked to rate the content of  
434 the image on three scales – ‘calm/excited’, ‘unpleasant/pleasant’, ‘not dominant/dominant’ (data  
435 not analysed).

436 *General memory recall (Sessions 1 and 2):* A surprise free recall based on the picture presentation  
437 was implemented in both sessions. The surprise element ensured consistency between the general  
438 and meal memory recall tasks. Participants were given 5 minutes to recall as many of the picture  
439 text labels as they could remember from the session 1 picture set at the end of the first session, and  
440 from both the session 2 set A and B picture presentations at the end of the second session.  
441 Participants were told to recall the exact text of each label in any order they wished, and to avoid  
442 recalling any related words or synonyms. A response was marked as correct if it was the same text,  
443 with the exception of pluralising the word or recalling the text label correctly, but with incorrect  
444 spelling. The dependent variable was the number of text labels correctly recalled for each  
445 presentation set.

446 *Dutch Eating Behavior Questionnaire (Session 1):* The same as in Study 1. The three subscales are  
447 restraint ( $\omega t = .96$ ), emotional eating ( $\omega t = .95$ ), and external eating ( $\omega t = .90$ ).

448 *Expected Satiety Memory measure (Session 2):* To measure memory for satiety, participants  
449 completed a computerised task in which they were asked to select the portion size of 18 meal foods  
450 to indicate the amount of food that would be required to produce the sensation of fullness that they  
451 experienced after lunch; adapted from Brunstrom, Shakeshaft, and Scott-Samuel (2008). Food  
452 pictures started at 20 kcal and increased in 20 kcal increments up 1000 kcal. Participants completed  
453 this measure twice in session 2: once immediately after consuming their lunch meal and again at the  
454 end of the test session. The outcome measure for this task was the absolute score of the average of

455 the kcal differences of the portion sizes selected between the two measures. A score of zero means  
456 there was no difference in portion size selection between the two time points, indicating perfect  
457 memory, larger scores indicate poorer memory. Participants were also asked whether they had  
458 consumed each of the food items to check for familiarity (referred to as the familiarity task in the  
459 procedure section).

460 *Visual memory for portion size (Session 2):* Participants were presented with a large bowl of pasta  
461 salad (twice the amount of the same pasta salad they were served for lunch). Participants were  
462 asked to self-serve the amount of food which they believe they were served earlier for lunch, from  
463 the bowl onto a plate. The outcome measure was the difference between the amount of pasta self-  
464 served and the actual amount of pasta served at lunch, converted into an error percentage (a  
465 percentage of zero indicating zero difference). A larger error percentage indicates a greater  
466 difference between the amount of pasta self-served and the actual amount served for lunch,  
467 indicating poorer memory for portion size.

468 *Timeline Follow Back (Session 1):* The same as in Study 1.

469 *Alcohol Use Disorders Identification Test (Session 1):* The same as in Study 1. ( $\omega = .82$ ).

470 *Snack Urge Scale (Session 2):* The same as in Study 1

471 *Appetite Ratings (Session 2):* The same as in Study 1.

#### 472 3.1.4. Procedure

473 Test sessions took place between 13:15 and 18:30 on weekdays in the Department of Psychology on  
474 the University of Liverpool campus. The study was advertised as investigating 'alcohol's effect on  
475 visual and taste perception'. Prior to both session 1 and 2, participants were told to consume a light  
476 meal approximately an hour before the beginning of each session. Upon arrival of session 1,  
477 participants were presented with the information sheet and provided informed consent. Participants  
478 were then asked to report when they had last eaten and what they had consumed. Participants then

479 completed a medical history questionnaire to assess whether they had any food allergies. Height and  
480 weight measurements were then taken in order to calculate the volume of drink to be consumed.  
481 Next, participants consumed the test drink (a soft drink for all participants) in three separate  
482 servings in 5-minute intervals. Afterwards, a 10-minute absorption period was completed whereby  
483 participants sat quietly. Next, participants consumed the test meal, and then completed the picture  
484 presentation task. Afterwards, participants completed the AUDIT and TLFB. Next, there was an  
485 approximately 132-minute break during which participants were asked to abstain from eating. We  
486 incorporated a longer break in Study 2 in order to further reduce alcohol levels in session 2 which  
487 may otherwise confound subsequent recall. After the break, participants completed the taste test,  
488 general memory recall task and DEBQ.

489 After at least 1 week, participants completed session 2. Firstly, participants completed a baseline  
490 breathalyser measure (all had a BrAc of 0.00), and baseline appetite and snack urge ratings. For  
491 participants in the soft drink and pre-meal drink conditions, they were then shown the pre-drink  
492 picture presentation and consumed their test drink (served in the same way as in session 1),  
493 followed by a 10-minute absorption period. They were then shown the post-drink picture  
494 presentation. Afterwards, they consumed their lunch meal before completing the first expected  
495 satiety memory task, and a second set of appetite and snack urge ratings. After this, participants  
496 completed a 2.5-hour break where they were asked to stay in the building and to abstain from  
497 eating. Participants in the soft drink condition were given the option of staying in the building or  
498 leaving and coming back after the break due to there being no ethical requirement to stay.  
499 Participants in the post-meal drink condition, after completing the baseline ratings, were shown the  
500 pre-drink picture presentation, then consumed their lunch meal, followed by the first expected  
501 satiety memory task and ratings of appetite and snack urge. Next, they consumed their test drink,  
502 followed by an absorption period and were then shown the post-drink picture presentation,  
503 followed by a 2-hour break. The break duration was calculated such that the inter-meal interval  
504 between the lunch meal and taste test was the same across conditions. After the break, participants

505 in all conditions completed a new set of appetite and snack urge ratings and then the taste test. This  
506 was followed by the general memory recall task, the second expected satiety memory task and its  
507



508 familiarity task, the visual memory for portion size task, vividness rating, awareness check, study

509 debrief and reimbursement.

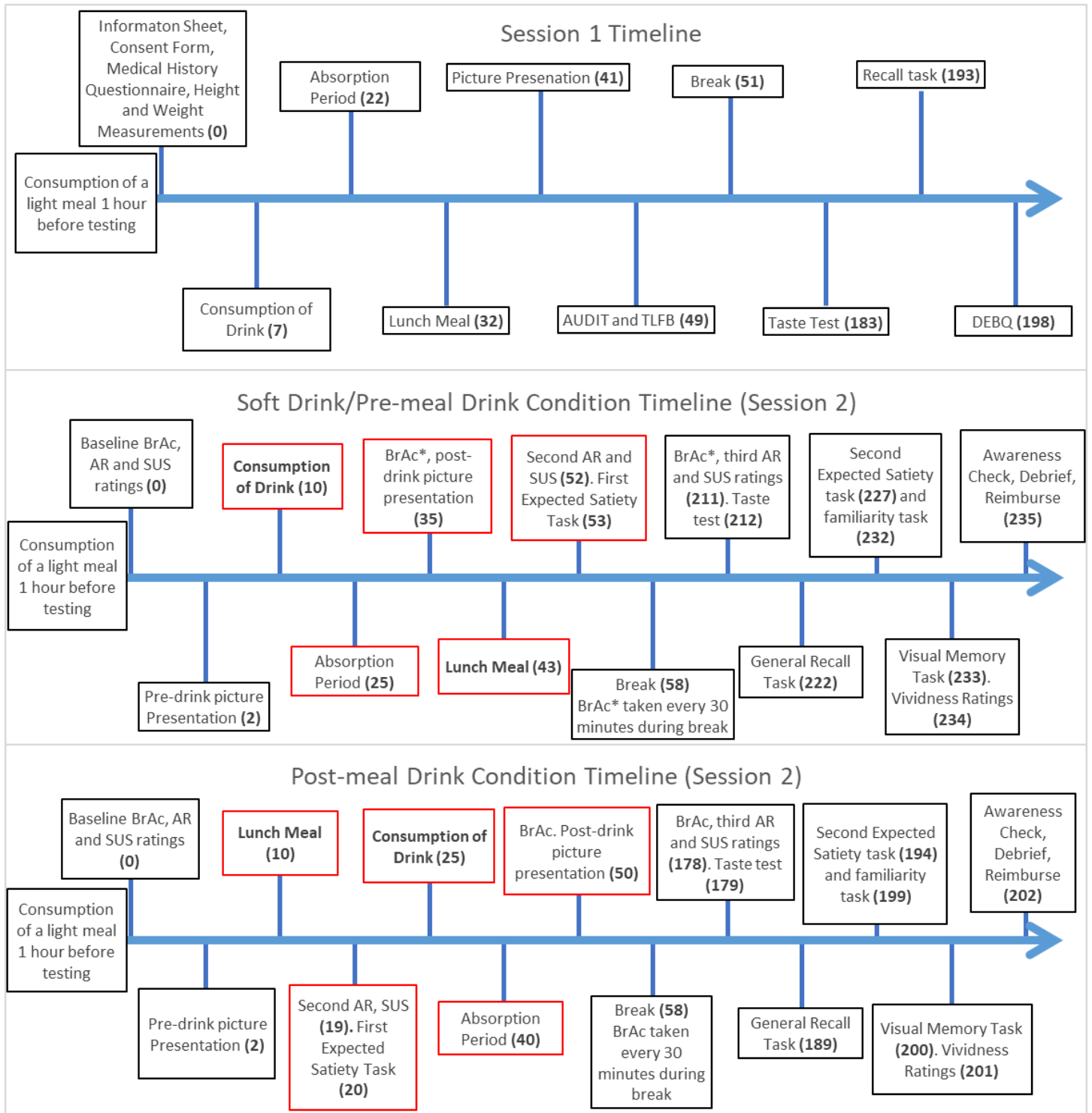


Figure 2. Schematic overview of the procedures for session 1 and session 2. Note. The procedure of session 1 was identical for all participants. Number in brackets represents the time (minutes) at which the task/measure was performed (relative to the start of the session). AR = Appetite Ratings; SUS = Snack Urge Scale ratings; BrAc = measure of breath alcohol concentration. \*The procedure in the soft drink condition was identical to the pre-meal condition, except no BrAc measures were taken apart from at baseline. Times are approximate. Boxes in red highlight where the order of tasks differs between the soft drink/pre-meal and post-meal drink condition.

### 510 3.1.5. Data Analysis

511 We analysed food intake using an ANCOVA with drink as the between-subjects factor and baseline  
512 (session 1) caloric cookie intake as a covariate. Performance on each meal memory measure was  
513 compared across drink conditions using one-way ANOVAs. For the expected satiety memory  
514 measure, foods which had been previously consumed by less than 50% of participants were  
515 excluded from this analysis, as has been done in previous research (Whitelock et al., 2018). Only 34%  
516 of participants had previously consumed grilled fish, therefore this item was excluded, leaving 17  
517 food items for the analysis. For the general memory task, a mixed-design ANOVA was conducted to  
518 test for a drink by set interaction effect. Mixed ANOVAs were conducted to observe differences  
519 between drink conditions and differences across time for appetite ratings and snack urge ratings  
520 (see findings of snack urge ratings in the supplementary materials). Data for cookie intake from one  
521 participant from session 2 were lost due to human error, one participant did not complete the  
522 AUDIT questionnaire and one participant did not complete post-lunch snack urge ratings.

## 523 3.2. Results

### 524 3.2.1. Participant characteristics

525 Means and standard deviations are displayed in Table 5.

526 Table 5. Sample characteristics split by drink condition (mean  $\pm$  SD).

	Soft Drink (N =24)	Pre-meal Drink (N = 24)	Post-meal Drink (N = 24)
BMI (kg/m <sup>2</sup> )	25.2 $\pm$ 4	24.6 $\pm$ 4.9	23.9 $\pm$ 4
Age (y)	27.6 $\pm$ 13.2	23.5 $\pm$ 6.6	21.8 $\pm$ 6.5
DEBQ Restraint	2.7 $\pm$ 1.1	2.3 $\pm$ 0.8	2.6 $\pm$ 1
DEBQ Emotional	2.5 $\pm$ 0.8	2.3 $\pm$ 0.7	2.5 $\pm$ 0.8
DEBQ External	3.2 $\pm$ 0.5	3.1 $\pm$ 0.6	3.1 $\pm$ 0.6
AUDIT (out of 40)	10.4 $\pm$ 6.6	9.9 $\pm$ 3.9	11.7 $\pm$ 5 <sup>1</sup>
7-day TLFB (alcohol units)	16 $\pm$ 12	19 $\pm$ 9	18 $\pm$ 8
Baseline General Memory Recall (Session 1; out of 24)	9 $\pm$ 2	9 $\pm$ 3	10 $\pm$ 2
Baseline Appetite (out of 200; Session 2)	112 $\pm$ 38	127 $\pm$ 36	106 $\pm$ 35
Baseline Snack Urge (out of 400; Session 2)	195 $\pm$ 67	202 $\pm$ 66	216 $\pm$ 55

527 Note. <sup>1</sup> = data missing from one participant. AUDIT = Alcohol Use Disorders Identification Test; BMI =  
528 Body Mass Index; DEBQ = Dutch Eating Behaviour Questionnaire; TLFB = Timeline Follow-back

529 3.2.2. Meal Memory measures (Table 6 and Figure 3)

530 There was a significant main effect of drink on expected satiety memory scores  $F(2, 69) = 4.67, p =$   
531  $.013, \eta_p^2 = .12$ . Bonferroni corrected pairwise comparisons revealed that the error score (higher  
532 scores indicating poorer memory) was significantly greater in the pre-meal drink condition,  
533 compared with the soft drink condition ( $p = .016$ ; 95% CI [-81.52, -6.42]) (see Figure 3). No other  
534 significant main effects of drink condition were found for any other meal memory measure.

535 3.2.2.1 Sensitivity Analysis

536 With removal of outliers for the expected satiety error measure, the main effect remained  
537 statistically significant, as did the difference between the pre-meal and soft drink condition ( $p = .007$ ;  
538 95% CI [-67.58, -8.53]). Additionally, error scores were significantly greater in the pre-meal drink  
539 condition compared with the post-meal drink condition ( $p = .018$ ; 95% CI [-63.54, -4.49]).

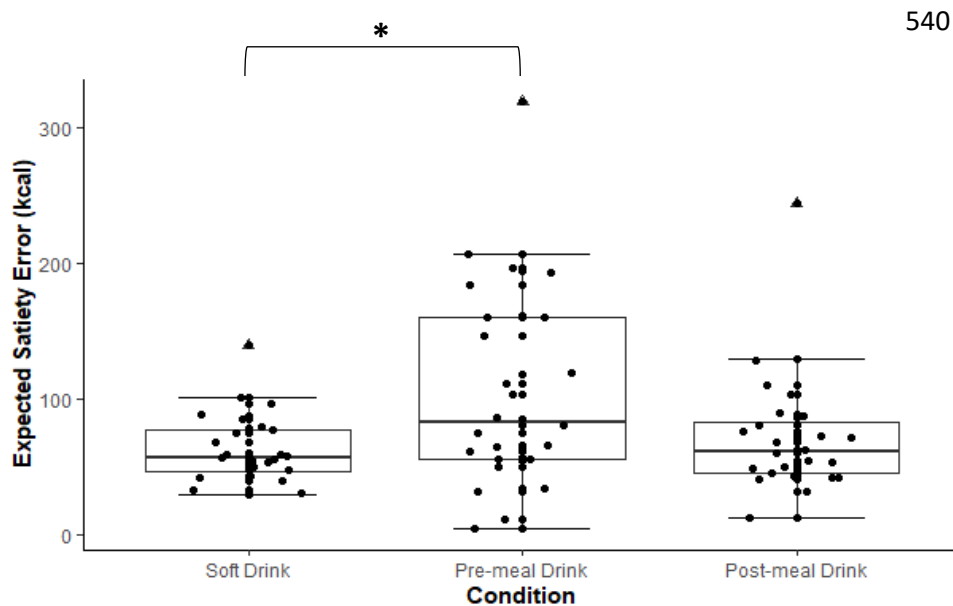


Figure 3. Boxplot displaying individual data points of expected satiety error scores, split by the three drink conditions. Note.  $*p < .05$ . Triangles represent outliers.

547

548

549

550 3.2.3. Calorie intake (Table 6):

551 An ANCOVA with baseline cookie intake as a co-variate revealed a non-significant main effect of  
 552 drink on cookie intake  $F(2, 67) = 0.49, p = .617, \eta_p^2 = .01$ . Using the same ANCOVA model, total  
 553 calorie intake significantly differed between drink conditions  $F(2, 67) = 29.86, p < .001, \eta_p^2 = .47$ .  
 554 Bonferroni corrected pairwise comparisons revealed that total caloric consumption was significantly  
 555 lower in the soft drink condition compared with both the pre-meal drink ( $p < .001$ ; mean difference  
 556 = 324.83; 95% CI [-441.69, -207.97]) and post-meal drink condition ( $p < .001$ ; mean difference =  
 557 313.89; 95% CI [-443.05, -195.72]). Total calorie intake did not differ between the pre-meal and post-  
 558 meal condition ( $p = 1.00$ ; mean difference = 10.95; 95% CI [-107.27, 129.16]). See table 6 for means  
 559 and standard deviations of caloric intake.

560 Table 6. Outcome measures, split by drink condition (mean  $\pm$  SD)

	Soft Drink (N = 24)	Pre-meal Drink (N = 24)	Post-meal Drink (N = 24)
Vividness ratings (session 2; out of 100)	80 $\pm$ 14	72 $\pm$ 19	79 $\pm$ 12
Expected satiety error (kcal)	64 $\pm$ 26 <sup>a</sup>	108 $\pm$ 76 <sup>a</sup>	72 $\pm$ 45
Visual Memory (%)	21.1 $\pm$ 14.3	14.8 $\pm$ 10.4	14.3 $\pm$ 10.3
Baseline <i>ad libitum</i> food Intake (kcal; Session 1)	293 $\pm$ 164	298 $\pm$ 135	281 $\pm$ 211
<i>Ad libitum</i> food Intake (kcal; Session 2)	358 $\pm$ 215	401 $\pm$ 197	384 $\pm$ 216 <sup>1</sup>
Drink and <i>ad libitum</i> intake combined (kcal; Session 2)	364 $\pm$ 215 <sup>d,e</sup>	693 $\pm$ 212 <sup>d</sup>	667 $\pm$ 228 <sup>e,1</sup>

561 Note. Means with the same letter indicate a significant difference between each other;  $p < .05$ ,  
 562 Bonferroni adjustment for multiple comparisons. <sup>1</sup> = data missing from one participant.

563

564 3.2.4. General memory recall (Figure 4):

565 For this analysis, we wanted to explore whether recall in the pre-drink set was greater in the two  
 566 alcohol conditions relative to the soft drink condition, but greater in the soft drink condition relative  
 567 to the two alcohol conditions in the post-drink set. Therefore, only the interaction effect is relevant.  
 568 A 2 (set; pre-drink, post-drink) x 3 (drink; soft drink, pre-meal drink, post-meal drink) mixed ANOVA  
 569 revealed a significant set by drink interaction  $F(2,69) = 8.26, p = .001, \eta_p^2 = .19$ . Univariate ANOVAs  
 570 were conducted for each set separately (see figure 3 for general memory recall of the pre-drink and  
 571 post-drink sets). A significant main effect of drink in the pre-drink set  $F(2,69) = 4.39, p = .016, \eta_p^2 =$

572 .11 was found, whereby recall in the post-meal drink condition was significantly greater than in the  
 573 pre-meal drink condition ( $p = .029$ ; mean difference = 2.71; 95% CI [0.21, 5.21]). This was  
 574 unexpected, as, due to a predicted effect of retrograde facilitation, we expected recall in the pre-  
 575 drink set to be significantly greater in both alcohol conditions (i.e. the pre-meal and post-meal  
 576 conditions), compared with the soft drink condition. There was also a significant main effect of drink  
 577 condition in the post-drink set  $F(2,69) = 11.03, p < .001, \eta_p^2 = .24$ , whereby recall in the pre-meal  
 578 drink condition was significantly lower than in both the soft drink condition ( $p < .001$ ; mean  
 579 difference = 3.46; 95% CI [1.65, 5.27]) and the post-meal condition ( $p = .046$ ; mean difference = 1.83;  
 580 95% CI [0.03, 3.64]). There was a nonsignificant difference between the soft drink and post-meal  
 581 conditions ( $p = .092$ ; mean difference = 1.63; 95% CI [-0.18, 3.43]).

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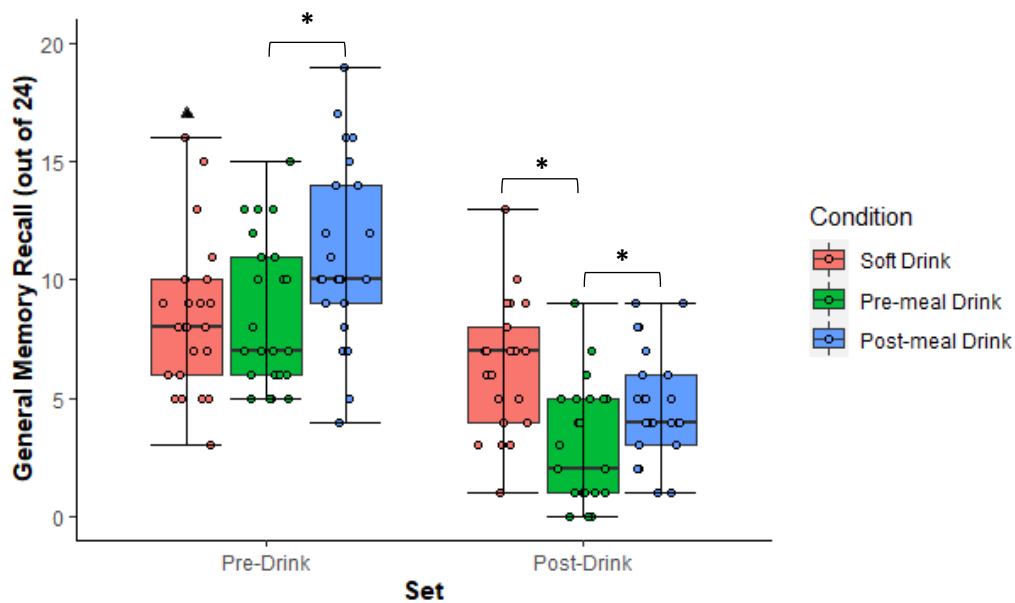
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590 Figure 4. Boxplot displaying individual data points of general memory recall split by the  
 591 three drink conditions, and two set types in session 2. Note.  $*p < .05$ . Triangles represent  
 592 outliers.

590

591 3.2.5. Appetite Ratings

592 A 3 (drink; soft drink, pre-meal drink, post-meal drink) x 3 (time; baseline, post-lunch, post-break)  
593 mixed ANOVA was conducted with drink as a between-subjects factor and time as a within-subjects.  
594 This revealed a main effect of time  $F(2, 138) = 71.31, p < .001, \eta_p^2 = .51$ . Bonferroni corrected  
595 pairwise comparisons revealed that appetite ratings were significantly greater at baseline than post-  
596 lunch ( $p < .001$ ; mean difference = 62; 95% CI [49, 75]) but did not differ from post-break ratings ( $p =$   
597  $.713$ ; mean difference = 7; 95% CI [-8, 22]). Post-lunch appetite ratings were significantly lower than  
598 post-break ratings ( $p < .001$ ; mean difference = 55; 95% CI [-68, -41]). The analysis also revealed a  
599 significant main effect of drink  $F(2,69) = 4.01, p = .023, \eta_p^2 = .10$ . Bonferroni corrected comparisons  
600 revealed that those in the soft drink condition had lower overall appetite ratings compared with the  
601 pre-meal drink condition ( $p = .029$ ; mean difference = 22; 95% CI [-43, -2]) but did not significantly  
602 differ from the post-meal drink condition ( $p = 1.00$ ; mean difference = 4; 95% CI [-25, 17]). Overall  
603 appetite ratings between the pre-meal and post-meal drink condition did not significantly differ ( $p =$   
604  $.100$ ; mean difference = 18; 95% CI [-39, 2]). Lastly, there was a nonsignificant drink x time  
605 interaction effect  $F(4, 138) = 2.07, p = .088, \eta_p^2 = .06$ . See supplementary materials for full list of  
606 means and standard deviations of appetite ratings at each time point, split by condition.

607

#### 4. General Discussion

608 Study 2 found that consumption of an alcoholic drink prior to consuming a lunch meal impaired meal  
609 memory when compared with consumption of a soft drink. In Study 2, this was evident for the  
610 measure of memory of satiety; participants in the pre-meal drink condition less accurately  
611 remembered the level of fullness experienced immediately after the lunch meal compared with  
612 those in the soft drink condition, as did those in the post-meal drink condition after removing  
613 outliers. However, this impairment was not evident for meal vividness ratings or visual memory of  
614 the portion size. Furthermore, the findings failed to show an enhanced recall of meal memory when  
615 the alcoholic drink was consumed after the lunch meal. There were also no significant differences in  
616 *ad libitum* food intake between the three conditions. Therefore, our hypothesis that meal memory

617 would be lowest in the pre-meal drink condition is only partially supported, with no support to show  
618 that this increased food intake. Furthermore, our hypothesis predicting that those in the post-meal  
619 drink condition would show the greatest meal memory and lowest food intake is rejected.

620 Study 2, but not Study 1, showed evidence that consumption of an alcoholic drink before a lunch  
621 meal can impair certain forms of meal memory compared with memory performance after  
622 consumption of an alcohol-free drink. Altering episodic memories of a recent meal is therefore an  
623 additional factor which is both caused by acute alcohol consumption and which, in other studies, has  
624 been shown to increase food intake. However, in both Study 1 and 2 we found no significant  
625 difference in food intake between drink conditions, therefore this proposition remains unsupported.

626 The present findings add to the literature by implementing a novel form of meal memory disruption.  
627 By using alcohol intoxication as a tool to manipulate and disrupt the encoding phase of memory  
628 formation, findings revealed that this was successful in altering the quality of some meal memories.  
629 It also provides support for previous literature which has shown that different methods of  
630 disruptions to memory encoding impair meal recall (Higgs & Woodward, 2009; Mittal, Stevenson,  
631 Oaten, & Miller, 2011; Oldham-Cooper, Hardman, Nicoll, Rogers, & Brunstrom, 2010). The present  
632 findings also highlight the difficulty in identifying the components of meal memory which are  
633 important in determining later food intake, as although a meal memory impairment was observed in  
634 Study 2, food intake did not differ between conditions. However, this does not mean that meal  
635 memory is unimportant in determining food intake. Instead, it is possible that other components of  
636 meal memory, such as visual memory of portion size may be a more important determinant in food  
637 intake. The memory manipulation used in the present study did not appear to be strong enough in  
638 order to impair recall of all measured forms of meal memory, which may explain a lack of effect on  
639 food intake. Future research should continue to investigate which components of meal memory  
640 directly relate to subsequent food intake.

641 As discussed elsewhere (Whitelock et al., 2019), it is important to consider how motivated  
642 participants were to use recent memories of their lunch when deciding how much to eat in the taste  
643 test. One reason why memory of recent eating did not lead to a reduction in food intake could be  
644 due to the calorie content of the pre-load lunch meal. Pre-load meals in both Study 1 and 2 did not  
645 exceed 515 kcal. For some participants this may be considered a relatively small amount of food and  
646 therefore, after an inter-meal interval of 160 minutes (as was the case in Study 2), participants may  
647 not have felt motivated to restrict their food intake even when details of this lunch meal were well-  
648 remembered. There is some evidence to suggest sex differences may exist with regard to the  
649 effectiveness of manipulating meal memory on subsequent food intake. For example, the effect of  
650 focused attention has been established in female samples (Higgs & Donohoe, 2011; Robinson,  
651 Kersbergen, & Higgs, 2014), but is inconsistent in mixed sex samples (Seguias & Tapper, 2018;  
652 Whitelock et al., 2018) and has not been found in a male sample (Whitelock et al., 2019). One  
653 explanation for why Seguias and Tapper (2018) found a difference in food intake in a mixed-sex  
654 sample may be due to the caloric quantity of the pre-load used. In their study, participants were  
655 given *ad libitum* access to their lunch meal. This would have allowed participants to consume a  
656 personally 'normal' amount of food. This in turn may have resulted in the sample being more  
657 motivated to use episodic meal memory when deciding how much to consume at a subsequent  
658 eating episode. This suggestion is speculative, however future studies may wish to investigate how  
659 altering the personal appropriateness of a pre-load meal in terms of its caloric content, can  
660 moderate the effect of episodic memories on later food intake.

661 Findings of Study 2 failed to show evidence of enhanced meal memory recall when the meal was  
662 consumed prior to alcohol consumption. The magnitude of the retrograde facilitation effect may  
663 differ depending on the type of stimuli exposed to. For example, Weafer et al. (2016) found that the  
664 effect of consolidation was greatest for neutral stimuli ( $d = 0.79$ ) compared with negative ( $d = 0.26$ )  
665 and positive ( $d = 0.31$ ) stimuli. It is plausible to assume that food-related stimuli may not be  
666 considered neutral. Therefore, as Study 2 was powered to detect a large effect size, we may have



667 been underpowered to detect consolidation effects of other, non-neutral stimuli. However, we also  
668 failed to find a consolidation effect for general memory recall, suggesting an overall failure in  
669 producing this effect.

670 Alternatively, a failure to detect enhanced meal memory may have resulted from the experimental  
671 design. By using the same test lunch in both the first and second session, participants may have  
672 already established a memory of the lunch meal from the first session, allowing participants to  
673 remember back to the previous session to recall details of their lunch meal, therefore minimising the  
674 importance of the effect of the drink on memory formation. Although we incorporated a 1-week  
675 washout period to counter this issue, some participants may still have remembered the quantity of  
676 the lunch meal. This may explain why no differences were found for the visual memory and vividness  
677 measures. However, in the case of the expected satiety memory measure, this was shown to be  
678 significantly impaired in the pre-meal drink condition relative to the soft drink condition. It may be  
679 that memory for fullness more difficult to remember between sessions, compared with other forms  
680 of meal memory.

681 There are some limitations with Study 2. Firstly, during the break in the second session, participants  
682 in the soft drink condition were not required to wait in a waiting room during the break. Although all  
683 participants were told to abstain from eating, some participants in this condition would have had a  
684 different experience during their break compared to participants in the other conditions, although  
685 no significant difference in food intake was found. A second limitation was that during the recall  
686 phase, participants in both alcohol conditions were on the descending limb of the blood alcohol  
687 curve (see supplementary materials for BrAc scores). The descending limb can produce sedation,  
688 negative mood (Babor et al., 1983; Lukas et al., 1986; Sukter et al., 1983) and impairment of certain  
689 forms of executive functioning (Pihl et al., 2003). One way to overcome this issue and to ensure  
690 participants were sober at the point of recall would have been to implement a longer delay of 24 or  
691 48 hours after the exposure phase, which has been done in previous studies (Gawrylowicz et al.,

692 2017; Weafer, Gallo & De Wit, 2016). However, we decided to implement a shorter period as this  
693 was essential in order to observe the effect of meal memory on food intake. This is because previous  
694 research has shown that cueing participants of their lunch consumed on the previous day does not  
695 affect food intake, but cueing lunch which has been consumed on the same day reduces subsequent  
696 food intake (Higgs, 2002). This suggests that memories relating to food consumed only very recently  
697 can alter food intake. Therefore, a greater delay may have failed to tap into the effect of meal  
698 memory on food intake. Despite this, a difference in mood and executive performance may have  
699 contributed to a lack of enhanced recall through retrograde facilitation which may have been  
700 observed otherwise with a longer delay.

701 In conclusion, there was some evidence to suggest that consuming a lunch meal whilst intoxicated  
702 can impair subsequent recall of certain lunch details. However, neither study provided evidence that  
703 meal memory predicted subsequent food intake. It therefore remains unclear whether alcohol  
704 induced changes in meal memory contribute towards alcohol-induced overeating.

705

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## 723 References

724 Babor, T. F., Berglas, S., Mendelson, J. H., Ellingboe, J., & Miller, K. (1983). Alcohol, affect, and the  
725 disinhibition of verbal behavior. *Psychopharmacology*, *80*(1), 53-60.

726 Bisby, J. A., Leitz, J. R., Morgan, C. J., & Curran, H. V. (2010). Decreases in recollective experience  
727 following acute alcohol: A dose–response study. *Psychopharmacology*, *208*(1), 67.

728 Blundell, J., De Graaf, C., Hulshof, T., Jebb, S., Livingstone, B., Luch, et al. (2010). Appetite control:  
729 methodological aspects of the evaluation of foods. *Obesity reviews*, *11*(3), 251-270.

730 Brunstrom, J. M., Burn, J. F., Sell, N. R., Collingwood, J. M., Rogers, P. J., Wilkinson, L. L., ... &  
731 Ferriday, D. (2012). Episodic memory and appetite regulation in humans. *PloS one*, *7*(12),  
732 e50707.

733 Brunstrom, J. M., Shakeshaft, N. G., & Scott-Samuel, N. E. (2008). Measuring ‘expected satiety’ in a  
734 range of common foods using a method of constant stimuli. *Appetite*, *51*(3), 604-614.

735 Cains, S., Blomeley, C., Kollo, M., Rácz, R., & Burdakov, D. (2017). Agrp neuron activity is required for  
736 alcohol-induced overeating. *Nature communications*, *8*, 14014.

737 Caton, S. J., Ball, M., Ahern, A., & Hetherington, M. M. (2004). Dose-dependent effects of alcohol on  
738 appetite and food intake. *Physiology & behavior*, *81*(1), 51-58.

739 Caton, S. J., Marks, J. E., & Hetherington, M. M. (2005). Pleasure and alcohol: manipulating  
740 pleasantness and the acute effects of alcohol on food intake. *Physiology & behavior*, *84*(3),  
741 371-377.

742 Christiansen, P., Rose, A., Randall-Smith, L., & Hardman, C. A. (2016). Alcohol’s acute effect on food  
743 intake is mediated by inhibitory control impairments. *Health Psychology*, *35*(5), 518.

744 Clifton, P. G., Vickers, S. P., & Somerville, E. M. (1998). Little and often: ingestive behavior patterns  
745 following hippocampal lesions in rats. *Behavioral neuroscience*, *112*(3), 502.

746 Davidson, T. L., Kanoski, S. E., Walls, E. K., & Jarrard, L. E. (2005). Memory inhibition and energy  
747 regulation. *Physiology & behavior*, *86*(5), 731-746.

- 748 Gadah, N. S., Brunstrom, J. M., & Rogers, P. J. (2016). Cross-over studies underestimate energy  
749 compensation: the example of sucrose-versus sucralose-containing drinks. *Appetite*, *107*,  
750 398-405.
- 751 Gawrylowicz, J., Ridley, A. M., Albery, I. P., Barnoth, E., & Young, J. (2017). Alcohol-induced  
752 retrograde facilitation renders witnesses of crime less suggestible to  
753 misinformation. *Psychopharmacology*, *234*(8), 1267-1275.
- 754 Hannapel, R., Ramesh, J., Ross, A., LaLumiere, R. T., Roseberry, A. G., & Parent, M. B. (2019).  
755 Postmeal optogenetic inhibition of dorsal or ventral hippocampal pyramidal neurons  
756 increases future intake. *Eneuro*. ENEURO.0457-  
757 18.2018. <https://doi.org/10.1523/ENEURO.0457-18.2018>
- 758 Hardman, C. A., Rogers, P. J., Dallas, R., Scott, J., Ruddock, H. K., & Robinson, E. (2015). "Food  
759 addiction is real". The effects of exposure to this message on self-diagnosed food addiction  
760 and eating behaviour. *Appetite*, *91*, 179-184.
- 761 Hashtroudi, S., Parker, E. S., DeLisi, L. E., Wyatt, R. J., & Mutter, S. A. (1984). Intact retention in acute  
762 alcohol amnesia. *Journal of Experimental Psychology: Learning, Memory, and*  
763 *Cognition*, *10*(1), 156.
- 764 Higgs, S. (2002). Memory for recent eating and its influence on subsequent food  
765 intake. *Appetite*, *39*(2), 159-166.
- 766 Higgs, S., & Donohoe, J. E. (2011). Focusing on food during lunch enhances lunch memory and  
767 decreases later snack intake. *Appetite*, *57*(1), 202-206.
- 768 Higgs, S., & Spetter, M. S. (2018). Cognitive control of eating: the role of memory in appetite and  
769 weight gain. *Current obesity reports*, *7*(1), 50-59.
- 770 Higgs, S., Williamson, A. C., & Attwood, A. S. (2008). Recall of recent lunch and its effect on  
771 subsequent snack intake. *Physiology & behavior*, *94*(3), 454-462.
- 772 Higgs, S., Williamson, A. C., Rotshtein, P., & Humphreys, G. W. (2008). Sensory-specific satiety is  
773 intact in amnesics who eat multiple meals. *Psychological Science*, *19*(7), 623-628.
- 774 Higgs, S., & Woodward, M. (2009). Television watching during lunch increases afternoon snack  
775 intake of young women. *Appetite*, *52*(1), 39-43.
- 776 Hull, J. G., & Bond, C. F. (1986). Social and behavioral consequences of alcohol consumption and  
777 expectancy: a meta-analysis. *Psychological bulletin*, *99*(3), 347.
- 778 Knowles, S. K. Z., & Duka, T. (2004). Does alcohol affect memory for emotional and non-emotional  
779 experiences in different ways?. *Behavioural pharmacology*, *15*(2), 111-121.
- 780 Kwok, A., Dordevic, A. L., Paton, G., Page, M. J., & Truby, H. (2019). Effect of alcohol consumption on  
781 food energy intake: A systematic review and meta-analysis. *British Journal of Nutrition*,  
782 *121*(5), 481-495.
- 783 Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). International affective picture system (IAPS):  
784 digitized photographs, instruction manual and affective ratings. Technical Report A-6,  
785 *Gainesville, FL, University of Florida*.

- 786 Lukas, S. E., Mendelson, J. H., Benedikt, R. A., & Jones, B. (1986). EEG alpha activity increases during  
787 transient episodes of ethanol-induced euphoria. *Pharmacology Biochemistry and*  
788 *Behavior, 25*(4), 889-895.
- 789 Martin, C. S., Earleywine, M., Musty, R. E., Perrine, M. W., & Swift, R. M. (1993). Development and  
790 validation of the biphasic alcohol effects scale. *Alcoholism: Clinical and Experimental*  
791 *Research, 17*(1), 140-146.
- 792 Mittal, D., Stevenson, R. J., Oaten, M. J., & Miller, L. A. (2011). Snacking while watching TV impairs  
793 food recall and promotes food intake on a later TV free test meal. *Applied Cognitive*  
794 *Psychology, 25*(6), 871-877.
- 795 Nilsson, L. G., Bäckman, L., & Karlsson, T. (1989). Priming and cued recall in elderly, alcohol  
796 intoxicated and sleep deprived subjects: A case of functionally similar memory  
797 deficits. *Psychological Medicine, 19*(2), 423-433.
- 798 Oldham-Cooper, R. E., Hardman, C. A., Nicoll, C. E., Rogers, P. J., & Brunstrom, J. M. (2010). Playing a  
799 computer game during lunch affects fullness, memory for lunch, and later snack intake. *The*  
800 *American journal of clinical nutrition, 93*(2), 308-313.
- 801 Parker, E. S., Birnbaum, I. M., Weingartner, H., Hartley, J. T., Stillman, R. C., & Wyatt, R. J. (1980).  
802 Retrograde enhancement of human memory with alcohol. *Psychopharmacology, 69*(2), 219-  
803 222.
- 804 Pihl, R. O., Paylan, S. S., Gentes-Hawn, A., & Hoaken, P. N. (2003). Alcohol affects executive cognitive  
805 functioning differentially on the ascending versus descending limb of the blood alcohol  
806 concentration curve. *Alcoholism: Clinical and Experimental Research, 27*(5), 773-779.
- 807 Raben, A., Agerholm-Larsen, L., Flint, A., Holst, J. J., & Astrup, A. (2003). Meals with similar energy  
808 densities but rich in protein, fat, carbohydrate, or alcohol have different effects on energy  
809 expenditure and substrate metabolism but not on appetite and energy intake. *The American*  
810 *journal of clinical nutrition, 77*(1), 91-100.
- 811 Robinson, E., Kersbergen, I., & Higgs, S. (2014). Eating 'attentively' reduces later energy consumption  
812 in overweight and obese females. *British Journal of Nutrition, 112*(4), 657-661.
- 813 Röjdmarm, S., Calissendorff, J., & Brismar, K. (2001). Alcohol ingestion decreases both diurnal and  
814 nocturnal secretion of leptin in healthy individuals. *Clinical endocrinology, 55*(5), 639-647.
- 815 Saunders, J. B., Aasland, O. G., Babor, T. F., De la Fuente, J. R., & Grant, M. (1993). Development of  
816 the alcohol use disorders identification test (AUDIT): WHO collaborative project on early  
817 detection of persons with harmful alcohol consumption-II. *Addiction, 88*(6), 791-804.
- 818 Seguias, L., & Tapper, K. (2018). The effect of mindful eating on subsequent intake of a high calorie  
819 snack. *Appetite, 121*, 93-100.
- 820 Schrieks, I. C., Stafleu, A., Griffioen-Roose, S., de Graaf, C., Witkamp, R. F., Boerrigter-Rijneveld, R., &  
821 Hendriks, H. F. (2015). Moderate alcohol consumption stimulates food intake and food  
822 reward of savoury foods. *Appetite, 89*, 77-83.
- 823 Sobell, L. C., & Sobell, M. B. (1992). Timeline follow-back. In *Measuring alcohol consumption* (pp. 41-  
824 72). Humana Press, Totowa, NJ.

- 825 Söderlund, H., Parker, E. S., Schwartz, B. L., & Tulving, E. (2005). Memory encoding and retrieval on  
826 the ascending and descending limbs of the blood alcohol concentration  
827 curve. *Psychopharmacology*, *182*(2), 305-317.
- 828 Sutker, P. B., Tabakoff, B., Goist Jr, K. C., & Randall, C. L. (1983). Acute alcohol intoxication, mood  
829 states and alcohol metabolism in women and men. *Pharmacology Biochemistry and*  
830 *Behavior*, *18*, 349-354.
- 831 Tapper, K., & Seguias, L. (2020). The effects of mindful eating on food consumption over a half-day  
832 period. *Appetite*, *145*, 104495.
- 833 Van Strien, T., Frijters, J. E., Bergers, G. P., & Defares, P. B. (1986). The Dutch Eating Behavior  
834 Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating  
835 behavior. *International journal of eating disorders*, *5*(2), 295-315.
- 836 Weafer, J., Gallo, D. A., & De Wit, H. (2016). Acute effects of alcohol on encoding and consolidation  
837 of memory for emotional stimuli. *Journal of studies on alcohol and drugs*, *77*(1), 86-94.
- 838 White, A. M., Matthews, D. B., & Best, P. J. (2000). Ethanol, memory, and hippocampal function: a  
839 review of recent findings. *Hippocampus*, *10*(1), 88-93.
- 840 Whitelock, V., Gaglione, A., Davies-Owen, J., & Robinson, E. (2019). Focused attention during eating  
841 enhanced memory for meal satiety but did not reduce later snack intake in men: A  
842 randomised within-subjects laboratory experiment. *Appetite*, *136*, 124-129.
- 843 Whitelock, V., Higgs, S., Brunstrom, J. M., Halford, J. C., & Robinson, E. (2018). No effect of focused  
844 attention whilst eating on later snack food intake: Two laboratory  
845 experiments. *Appetite*, *128*, 188-196.
- 846 Wixted, J. T. (2005). A theory about why we forget what we once knew. *Current Directions in*  
847 *Psychological Science*, *14*(1), 6-9.
- 848 Yeomans, M. R. (2010). Alcohol, appetite and energy balance: is alcohol intake a risk factor for  
849 obesity?. *Physiology & behavior*, *100*(1), 82-89.
- 850 Zola-Morgan, S., Squire, L. R., & Amaral, D. G. (1986). Human amnesia and the medial temporal  
851 region: enduring memory impairment following a bilateral lesion limited to field CA1 of the  
852 hippocampus. *Journal of Neuroscience*, *6*(10), 2950-2967.
- 853