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The role of memory ability, depth and mode of recall in the impact of memory on later consumption

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ABSTRACT

It has been shown that recalling a meal eaten a few hours earlier (vs. the previous day) leads to reduced snacking ('meal-recall' effect). This study attempted to replicate this effect, by assessing participants' (N = 77, mean age = 33.30 [SD = 14.98], mean BMI = 23.77 [SD = 3.72], 74% female) biscuit consumption during a bogus taste test in two separate sessions, before which participants recalled a recent or a distant meal. It was explored whether factors that might affect the quality of a meal-memory, particularly individual differences in memory ability and depth of recall, would influence the meal-recall effect. To this end, only participants with a low or high memory ability were recruited for the study and were allocated to either an unguided-recall or guided-recall condition. In the unguided condition, participants were asked to recall what they ate, and in the guided condition they were prompted for further details regarding their meal. Participants were asked to either recall their meal out loud through an interview with the experimenter or by writing their recollection down on the computer. Contrary to the initial hypotheses, it was found that only the written group demonstrated the meal-recall effect, whereas the verbal group did not. Moreover, this was specific to the written, unguided group, in which participants ate about 9 g fewer biscuits after recalling a recent (vs. a distant) meal, $F\,(1,15) = 6.07$, $p = .026$, $\eta_p^2 = 0.288$. The written, guided group's snacking seemed to *increase* by about 8 g after recalling a recent (vs. a distant) meal, $F\,(1,20) = 7.31$, $p = .014$, $\eta_p^2 = 0.268$. The meal-recall effect was not evident in the verbal group. Memory ability did not influence the magnitude of the meal-recall effect. The results highlight the importance of contextual factors in modulating the meal-recall effect.

1. Introduction

It is increasingly understood that cognitive processes, including memories of past meals, play a significant role in appetite control and consumption regulation (Higgs, 2015; Higgs & Spetter, 2018; Martin & Davidson, 2014). It has been shown that recalling a meal consumed earlier in the day can reduce subsequent snacking, relative to recalling a more distant meal (e.g. lunch eaten the previous day) or a non-food memory, such as a journey into the lab (i.e. the 'meal-recall' effect; Higgs, 2002; Higgs, Williamson, & Attwood, 2008).

1.1. The meal-recall effect

In one study investigating the meal-recall effect, Higgs (2002) allocated female undergraduates to one of three conditions: recalling a meal from the same day (today's lunch), recalling a meal from the previous day (yesterday's lunch), or thinking about anything they want. Participants were asked to spend 5 min recalling today's/yesterday's lunch or thinking about anything they wanted and writing down these thoughts on a piece of paper. They were then given *ad libitum* access to biscuits as part of a bogus taste test. Participants who recalled today's lunch ate fewer biscuits than both those who recalled yesterday's lunch or a non-food event.

Further studies by Higgs and colleagues (Higgs, Williamson, & Attwood, 2008) revealed that the meal-recall effect was only evident for participant with low disinhibition scores and was not influenced by dietary restraint (experiment 2). Recalling a meal which was eaten an hour earlier did not elicit decrease snacking, but recalling one which was eaten 3 h earlier did (experiment 3). The authors thus concluded that some forgetting of the meal must occur for this effect to be elicited. This study sought to replicate the meal-recall effect and examine three other factors that might moderate the effect: mode of recall, memory ability, and recall depth.

1.2. Mode of recall

Previous studies (Higgs, 2002; Higgs, Williamson, & Attwood, 2008) instructed participants to recall their meal by writing it down. We explored whether the meal-recall effect is also observed when participants are asked to recall their meal verbally. We hypothesised that the meal-recall effect would be present in both recall modes and that the data could be collapsed across these groups for analysis. Testing the robustness of the meal-recall effect to different modes of recall is important to inform the design of future studies related to this effect.

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1.3. Meal-memory quality

Not all memories are recalled with the same degree of intensity (Rubin & Kozin, 1984). The number of details recalled is sometimes used as a definition for memory vividness (Talarico, Labar, & Rubin, 2004), although it is important to note that the number of details does not always correlate with subjective vividness (Cooper, Kensinger, & Ritchey, 2019). It was therefore thought that recalling more meal-related details would produce better-quality memories, and that this would have a greater impact on eating behaviour. To date, only one study provided weak evidence that self-reported meal-memory vividness (assessed by a rating scale) was negatively correlated with snack intake (Higgs & Donohoe, 2011). To gain a more objective measure of memory vividness in the present experiment, the number of episodic details produced was used as a proxy for vividness. Following the Levine method (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002), the number of details produced was used as a manipulation check. We reasoned that since meal-memories are episodic in nature, more vivid memories would contain more episodic details.

To experimentally manipulate the vividness of meal-memory recall, participants were allocated to either the ‘unguided’ or the ‘guided’ meal-recall condition. Some researchers emphasise that the key defining features of an episodic memory are the contextual elements, frequently referred to as the ‘what, where, when’ (Clayton & Dickinson, 1998; Nyberg et al., 1996). Therefore, whereas the unguided-recall condition simply prompted participants to bring the meal-memory to mind, the guided-recall prompts aimed to encourage production of additional ‘what’, ‘when’ and ‘where’ details (e.g. texture, taste, location, company). We hypothesised that the guided condition would activate the meal-memory more and thus generate a stronger meal-recall effect (i.e. more prompts would further decrease snacking).

1.4. Memory ability

Individual differences in episodic memory ability are well documented (e.g. D'Argembeau & Van der Linden, 2006; Kirchhoff, 2009). For individuals with good episodic memory ability, recalling a memory might already be quite a ‘vivid’ experience, whereas it is likely those with poorer memories might be less immersed in their recollection (Kensinger, Addis, & Atapattu, 2011). Thus, natural variation in episodic memory ability may impact subsequent memory vividness at retrieval.

The present experiment pre-selected participants with either a low or a high episodic memory ability, to assess how individual differences may affect the relationship between meal-recall and subsequent consumption. It was hypothesised that those with better episodic memory ability were likely to spontaneously produce recollections rich in episodic details, even without direct prompts, whereas those with poorer episodic memories would not. It was hypothesised that the meal-recall effect would be weaker (or absent) for low-memory, unguided participants, than for high-memory, unguided participants. It was hypothesised that guided-recall might compensate for the difference in initial memory quality, reducing the difference between those with low and high memory ability. To control for additional individual differences in mental imagery ability (Poltrock & Brown, 1984), a visual imagery ability questionnaire was also administered and included as a covariate (Marks, 1973).

1.5. Hypotheses

We tested four main hypotheses. First, we hypothesised that when conditions were identical to the Higgs (2002) study (i.e. written-recall, unguided) we would replicate the finding that participants eat a smaller amount of biscuits after recalling a meal from earlier in the day, than when asked to recall a meal consumed on a previous day. Second, we hypothesised that the meal-recall effect would be robust to changes in recall mode and thus no differences in the presence or magnitude of the meal-recall effect between the written and verbal groups were anticipated. Third, we hypothesised that participants with a high episodic memory ability would have a stronger meal-recall effect than participants with a low episodic memory ability in the unguided-recall condition. Fourth, we hypothesised that encouraging participants to produce more detail in the guided-recall condition would decrease potential differences in the magnitude of the meal-recall effect between the two memory ability groups. Since those with a poorer episodic memory ability may be less immersed in their meal recollections (Kensinger et al., 2011), it was predicted that encouraging them to produce more detail through guidance would lead to a stronger meal-recall effect in the low memory group. Thus, a significant interaction between memory group and the level of guidance was hypothesised. We included measures of dietary restraint and disinhibition as potential covariates, based on previous findings (Higgs, Williamson, & Attwood, 2008) as well as a measure of visual imagery ability as a potential covariate which had not been previously explored in such research context. Pre- and post-recall hunger ratings (obtained from a mood questionnaire) were also included as an exploratory covariate, to assess whether recalling a past meal influenced hunger ratings.

2. Method

2.1. Participants

Participants were recruited from the University of Cambridge participant pool, social media platforms, posters in local community venues and newsletter announcements. The eligibility criteria were: scoring less than 30% (low memory) or more than 70% (high memory) on the Treasure-Hunt Task (THT; see below), no present or past diagnosis of eating disorders, willing to eat biscuits, and no food allergies. One hundred and seventy-three volunteers completed the screening session and 80 participants were eligible, of which 76 completed the two biscuit taste sessions. Data from seven participants (all from verbal, high memory, guided-recall group), collected by Cambridge University undergraduate students in a conceptually similar experiment in Autumn 2017, were included in the sample. Five participants were excluded because the z-score for the difference in biscuits eaten when recalling yesterday's and today's meal were greater than 1.96 or lower than −1.96 (i.e. critical z-score values for 95% confidence level). One participant was excluded because they guessed the aim of the study. Seventy-seven participants (57 female) were included in the final analysis. These participants were aged between 18 and 73 (M = 33.30, SD = 14.98) and the BMI range was 17.36–35.16 (M = 23.77, SD = 3.72). Most participants had a BMI within the normal range, between 18.5 and 24.9 kg/m^2 (64%), 34% had a BMI ≥ 25 kg/m^2 and 2% had a BMI < 18.5 kg/m^2.

Ethical approval was granted by the Cambridge Department of Psychology Research Ethics Committee. All participants read an information sheet, signed a participation consent form and were fully debriefed about the true aims of the study at the end. Participants were paid £5 for the pre-screen and £30 for the main study.

2.2. Study design

This was a mixed design study to test whether the meal-recall effect could be replicated, and whether it is moderated by recall mode, memory ability or the level of guidance. The dependent variable was biscuit intake during the bogus taste test. The within-subjects condition was recall-day (today's meal vs. yesterday's meal). The between-subjects conditions were memory ability (low vs high), level of guidance (guided vs unguided), and mode of recall (written vs verbal). Memory ability was determined at screening. Condition allocation (to level of guidance and mode of recall) was done pseudo-randomly, as the experimenter ensured that the spread of BMI, age and gender was approximately equal in each group.

2.3. Experimental conditions

Recalling a past meal was the key point of experimental manipulation. All participants were initially asked the same question: *'Could you please tell me what you had for breakfast/lunch today/yesterday? Please be specific about the ingredients and the amounts*'.

2.3.1. Day of recall

Each participant attended two separate testing sessions, several days apart. In a within-subject manipulation, each participant was asked either to recall today's most recent meal (lunch or breakfast) or the equivalent meal from the previous day. The order of these questions was counterbalanced between participants.

2.3.2. Mode of recall

In the verbal-recall condition, the experimenter read the questions out loud and waited for the participant to respond verbally. All answers were voice-recorded and transcribed. It was thought that if participants produced very short answers (e.g. "I had a sandwich"), the meal-recall effect might not have been elicited. If participants in the verbal-recall condition did not mention either the ingredients or the amount of food, the experimenter prompted them by repeating the appropriate part of the question once more (i.e. asked them to list the ingredients and/or the amounts). In the written-recall condition, participants saw the same questions displayed on a computer screen and responded by typing out their response in a box underneath the questions. The experimenter could not immediately check if the participant produced a detailed-enough response, and so a minimum response length of 30 characters was set.

2.3.3. Level of guidance

Participants in the guided-recall condition were asked ten additional questions pertaining to the episodic details of the event: i) *'what was the texture and the taste like?*', ii) *'what was the most predominant flavour of the meal?*', iii) *'what would you say had the weakest flavour?'* iv) *'was the food soft or crunchy?*', v) *'where did you have the meal?*', vi) *'who did you have the meal with?*', vii) *'which utensils did you use?*', viii) *'was there anything particularly memorable or enjoyable about the meal?*', ix) *'how did you feel when you had the meal?*', x) *'what was the temperature of the food like?*'.

2.4. Vividness coding

The number of internal details (i.e. those directly related to the eating episode; Levine et al., 2002) reported during the meal-recall was used as a proxy measure of memory vividness. For example, if a participant reported 'I had a <u>chicken</u> and <u>bacon sandwich</u> for lunch', this would be coded as three internal details. A detail was counted if a) it was novel and b) it contributed to the general understanding of the event. Repetitions, synonyms and re-phrasings were ignored. To assess interrater reliability, 10% of the transcripts were selected at random and coded by a different experimenter who was trained to use the same scoring technique. A two-way random intraclass correlation coefficient was calculated to assess the consistency of coder ratings. Interrater reliability was high at 0.934, $CI_{95\%}$ (0.812 - 0.977).

2.5. Measures

2.5.1. Memory ability

Episodic memory ability was assessed using the Treasure Hunt Task (THT) developed by Cheke, Simons, and Clayton (2016). The task was created using PsychoPy (Peirce, 2008) and involved placing and remembering the position of food items on a complex background image. The reader is directed to Cheke et al. (2016) for a full description of the task, however, as a brief explanation, the task is based on the premise that episodic memories are characterised by three main elements – 'what', 'where' and 'when' – and the integration between them (Clayton, Bussey, Emery, & Dickinson, 2003; Tulving, 1972). During the computer-based task, participants were asked to position ('hide') six different food items in six different places using the arrow keys, on a complex background (scene). The scene and food items were presented twice, as 'Day 1' and 'Day 2'. When participants had finished hiding items for Day 1, they were asked to position the same items, on the same background for Day 2, but each item had to be 'hidden' in a different place on the screen. The same task was repeated with a different set of food items and a different scene. Altogether, the participants hid 12 items in two scenes, each of which was presented twice (such that the order was 'Scene 1, Day 1', 'Scene 1, Day 2', 'Scene 2, Day 1', 'Scene 2, Day 2'). As such, the participants had to remember 24 unique item-location-session combinations.

Immediately after the last item was hidden, previously hidden food items appeared on the screen and the participants were asked to move the item to the correct hiding location for a specific 'day' using the arrow keys. The order of the scenes and days were the same as during the encoding phase 'Scene 1, Day 1', 'Scene 1, Day 2', 'Scene 2, Day 1', 'Scene 2, Day 2'. This way, each hiding location had to be retained for approximately the same period of time (about 4–5 min). The order in which the food items appeared was randomised. The participants were tested on all 24 item-location-session combinations and scored a point only when they recalled the exact item location. Participants scoring less than 8 ($\leq$30%) were classed as low memory ability and those scoring more than 17 ($\geq$70%) were classed as high memory ability, based on the upper and lower quartiles of all those participants who had previously completed the task (approx. N = 700, unpublished data).

2.5.2. Self-report questionnaires

Age, gender, and self-reported height and weight were collected by an online questionnaire (programmed in Qualtrics) and BMI (kg/m^2) was calculated. All participants completed The Dutch Eating Behaviour Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986) and The Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985) on a computer (programmed in Qualtrics). Participants completed a Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973), which assesses the extent to which an individual is able to form a mental visual representation of objects, sceneries and experiences (administered on paper). The participants read 16 statements and then rated how vividly they could 'perceive' the image in their mind's eye. Although Marks (1973) recommends completing the questionnaire twice, once with eyes opened and once with eyes closed, the participants only completed the VVIQ once for the sake of brevity and were not given any instructions regarding keeping their eyes closed or open (as in Reisberg, Pearson, & Kosslyn, 2003). A total VVIQ score was calculated for each participant by summing the responses given to all 16 questions (minimum score 16, maximum score 80). For clarity, the original scoring scheme was reversed, so that higher scores implied better imagery skills. In order to explore whether recalling a past meal influenced subjective hunger ratings, a mood questionnaire (programmed in Qualtrics) was administered to participants before and after they recalled a meal. The hunger rating was hidden among nine other mood attributes (e.g. excitement, sadness, happiness), which participants also rated before and after the meal. This was done to avoid making it obvious that hunger was the variable of interest and to make the ostensible aim of the study ('how does mood affect taste?') more credible. Each mood attribute was rated on a scale from 0 to 100.

2.5.3. Biscuit taste test

To disguise the fact that biscuit consumption was being measured, it was presented to the participants as a taste preference test. The experimenter put three boxes of biscuits in front of the participants, which were filled with approximately 100 g of Milk Chocolate Fingers (Cadbury, 516 kcal per 100 g), Digestives (McVities, 495 kcal per 100 g) or Chocolate Chip Cookies (Maryland, 487 kcal per 100 g). Biscuits were broken into small pieces to prevent participants from restraining their eating due to counting the number of biscuits consumed. The amount of biscuits provided ensured that participants would be able to snack on the biscuits without making the boxes appear empty, reducing the likelihood that they would restrain their eating due to social desirability. A 250 ml cup of water was provided. Participants were asked to rate the three types of biscuits on twelve different attributes, such as sweetness, crunchiness or saltiness. They were also informed that they were free to eat as many biscuits as they wished, since the biscuits would have to be disposed of at the end of the session for hygiene reasons. Participants completed the biscuit ratings and also rated how much they liked the biscuit they were tasting. This was used to control for baseline differences in biscuit liking. Ratings were made on a slider scale from 0 to 100, on an online questionnaire programmed in Qualtrics. Lastly, the participants were asked to report whether there was anything that could have influenced the amount of biscuits they ate (e.g. illness, stress). No participant reported a significant impact of external factors. At the end of each session the boxes of biscuits were weighed. The total amount of biscuits consumed was calculated by subtracting total biscuit weight at the end of the session, from the initial weight of the biscuits served.

2.6. Procedure

The experiment consisted of three sessions: the prescreen and the two biscuit taste sessions. All sessions took place in the laboratory at the University of Cambridge Department of Psychology. Participants were told that the aim of the experiment was to investigate how mood affects taste.

2.6.1. Prescreen session

Participants completed the demographics questionnaire, the TFEQ, and DEBQ questionnaires on the computer at their own pace (approximate completion time was 20 min). The experimenter then explained and guided the participants through a training version of the THT. Once the participant was confident that they understood the instructions, the experimenter started the real THT and moved away from the participant's computer screen, but remained in the room. The THT took about 10–15 min to complete. Once the participant finished the task, the experimenter calculated the THT score to assess whether the participant was eligible for the main study and the participant completed a pen and paper version of the VVIQ. If the participant was not eligible for the main study (i.e. received a score > 8 but < 17) they were thanked for their involvement and given a £5 Amazon voucher. Eligible participants were invited for two more sessions in the laboratory.

2.6.2. Main experimental sessions

The main experimental sessions occurred at (approximately) the same time of day across two separate days at least two days apart. Participants were instructed to have a meal at least 3 h before attending but not to eat following this. The core design followed that of Higgs (2002). Participants were seated in front of a computer and asked to complete the mood questionnaire. They were then asked to recall a previous meal. After recalling their meal, the participants were asked to complete the mood questionnaire again. The participants were then given 10 min to complete the biscuit taste test.

After the first session, the experimenter returned to the room, thanked the participants and reminded them about the second session. After the second session, the experimenter gave participants a questionnaire to assess whether they had deduced the real aims of the study. The questionnaire also asked participants to list anything that seemed out of place throughout the study and anything that might have changed their behaviour in significant ways. The experimenter then talked the participants through their responses and fully debriefed them. The participants received payment in the form of a £35 Amazon voucher and were thanked for their participation. They were also asked not to tell other people the true aim of the study.

2.7. Analysis plan

2.7.1. Manipulation checks

It was assessed whether the manipulations employed in the present experiment successfully differentiated participants in various conditions. Specifically, a set of one-way ANOVAs were conducted to confirm that the low and high memory groups had different THT scores and that more episodic details were produced in the guided-recall condition than in the unguided-recall. Since the meal-recall effect was not robust to changes in the mode of recall (i.e. verbal/written-recall), these tests were conducted separately for each recall mode.

2.7.2. Main hypotheses testing

The first hypothesis was that the meal-recall effect would be replicated in the written-recall, unguided group. To test this, a repeated-measures ANOVA, with biscuit intake after recalling today's and yesterday's lunch as the dependent variable was conducted. Then, a repeated-measures ANOVA was conducted and the interactions between the mode of recall, recall-day and level of guidance were examined. Another repeated-measures ANOVA was conducted to assess whether the meal-recall effect would be replicated in the verbal-recall, unguided group.

As the interaction between mode of recall, recall day, and depth of recall was significant, the remaining hypotheses were tested separately for each mode of recall. To examine the effects of memory ability and level of guidance on the meal-recall effect, repeated-measures ANOVAs, with biscuits intake after each recall-day (today vs. yesterday) as the dependent variable and memory group and the level of guidance as the independent variables. Interactions between variables were examined to assess how these manipulations influenced the meal-recall effect. Lastly, subjective hunger ratings (recorded before and after recalling today's and yesterday's meals), TFEQ disinhibition, DEBQ restraint and VVIQ scores were added as covariates to three separate repeated-measures ANOVAs (each conducted separately for the two modes of recall), to explore whether these factors modulated the relationship between meal-recall and subsequent snacking. All analyses were performed using IBM SPSS statistics version 25. Alpha was set at 0.05.

2.8. A priori power analysis

A power analysis was conducted using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) using the weight of biscuit intake for the 'lunch today' (M = 24.2, SD = 2.9) and 'lunch yesterday' (M = 47.6, SD = 6.0) conditions in Higgs (2002) as the input parameters. To detect a large effect size (which was reported by Higgs, 2002) with 95% power, 32 participants would be required (n = 4 for the 8 experimental groups). Given the complexity of this experiment, data from 80 participants was collected instead (n = 10 for the 8 experimental groups).

3. Results

3.1. Manipulation checks

It was checked whether participants in the two memory groups (low/high) had significantly different THT scores, and secondly it was assessed whether participants in the guided-recall condition produced more episodic details than those in the unguided-recall condition (Table 1). Since all of the subsequent main analyses were conducted separately for written-recall and verbal-recall groups, the manipulation checks were also divided in this way.

Table 1
Summary statistics of demographic variables in different experimental groups, according to mode of recall, memory group and level of guidance.

Verbal Recall					Written Recall			
	Low Memory		High Memory		Low Memory		High Memory	
	Unguided recall	Guided Recall	Unguided Recall	Guided Recall	Unguided Recall	Guided Recall	Unguided Recall	Guided Recall
N	10	10	10	10	8	10	8	11
Gender (M/F)	3/7	0/10	4/6	5/5	2/6	2/8	2/6	2/9
Age	31.20 (11.50)	41.50 (20.78)	29.80 (13.28)	23.10 (3.96)	44.50 (13.35)	35.10 (10.70)	32.13 (20.03)	31.27 (14.79)
BMI	26.08 (4.62)	24.09 (4.20)	23.51 (3.05)	21.96 (2.50)	24.62 (3.57)	23.75 (2.71)	22.41 (3.59)	23.65 (4.52)
Restraint (DEBQ)	1.98 (0.74)	2.58 (0.58)	2.45 (0.69)	1.88 (0.68)	2.68 (0.58)	2.50 (0.64)	2.79 (0.63)	2.60 (0.76)
Disinhibition (TFEQ)	5.40 (4.09)	6.90 (3.84)	6.40 (3.27)	3.40 (2.41)	5.13 (3.83)	5.00 (2.36)	5.88 (2.80)	7.36 (3.26)
VVIQ	60.70 (11.36)	60.40 (11.06)	59.30 (12.43)	55.60 (9.81)	58.13 (13.03)	57.80 (7.44)	59.00 (8.26)	57.00 (10.42)
THT Memory Score	.22 (0.06)	.20 (0.10)	.83 (0.10)	.82 (0.09)	.21 (0.09)	.23 (0.09)	.84 (0.11)	.84 (0.08)

Note. Standard Deviations are presented in parentheses.

3.1.1. Episodic memory ability

3.1.1.1. Written-recall. A one-way ANOVA revealed that THT scores of low ($M = 0.22$, $SD = 0.09$) and high ($M = 0.84$, $SD = 0.09$) memory participants were significantly different from each other, $F(1,35) = 451.88$, $p < .001$, $\eta_p^2 = 0.928$.

3.1.1.2. Verbal-recall. A one-way ANOVA revealed that THT scores of low ($M = 0.21$, $SD = 0.08$) and high ($M = 0.82$, $SD = 0.09$) memory participants were significantly different from each other, $F(1,38) = 492.16$, $p < .001$, $\eta_p^2 = 0.928$.

3.1.2. Depth of meal-memory

3.1.2.1. Written-recall. A one-way ANOVA revealed that when recalling today's meal, significantly more details were produced in the guided ($M = 25.76$, $SD = 9.20$) than the unguided ($M = 8.31$, $SD = 4.33$) recall group, $F(1,35) = 49.04$, $p < .001$, $\eta_p^2 = 0.584$. Similarly, when yesterday's meal was recalled, more details were generated in the guided ($M = 28.24$, $SD = 10.81$), than the unguided ($M = 7.56$, $SD = 4.30$) group, $F(1,35) = 51.94$, $p < .001$, $\eta_p^2 = 0.597$.

3.1.2.2. Verbal-recall. A one-way ANOVA revealed that when recalling today's meal, significantly more details were produced in the guided ($M = 32.90$, $SD = 12.70$) than the unguided ($M = 9.55$, $SD = 5.74$) recall group, $F(1,38) = 56.11$, $p < .001$, $\eta_p^2 = 0.596$. Similarly, when yesterday's meal was recalled, more details were generated in the guided ($M = 34.80$, $SD = 14.70$), than the unguided ($M = 9.75$, $SD = 4.27$) group, $F(1,38) = 53.60$, $p < .001$, $\eta_p^2 = 0.585$.

3.2. Main hypotheses testing

3.2.1. Replication of the original meal-recall effect

To investigate whether the original meal-recall effect (as described by Higgs, 2002) replicated, data from participants in the unguided-recall group only was used to conduct a repeated-measures ANOVA. Participants ate significantly fewer biscuits after recalling today's ($M = 53.81$, $SD = 43.07$) relative to yesterday's ($M = 62.88$, $SD = 46.25$) meal, $F(1,15) = 6.07$, $p = .026$, $\eta_p^2 = 0.288$, when the mode of recall was written (as in Higgs, 2002).

3.2.2. Mode of recall effects

A repeated-measures ANOVA revealed that the recall-day did not significantly interact with the mode of recall, $F(1,75) = 0.07$, $p = .795$. However, there was a significant interaction between the recall-day, mode of recall and depth of recall, $F(1,69) = 5.75$, $p = .019$, $\eta_p^2 = 0.077$. This suggests that the meal-recall effect manifested itself differently in the unguided and guided groups, depending on the mode of recall. A repeated-measures ANOVA assessed whether the meal-recall effect was also elicited in the verbal-recall, unguided condition. It was revealed that there were no significant differences in the amount of biscuits eaten after recalling today's ($M = 77.20$, $SD = 35.08$) or yesterday's ($M = 76.90$, $SD = 32.00$) meal, $F(1,19) = 0.01$, $p = .939$, when a verbal mode of recall was used. Contrary to the initial hypotheses, the two modes of recall produced different results, and it was decided that all subsequent analyses will be conducted separately for the verbal and written groups.

3.2.3. The role of guidance and memory

3.2.3.1. Written-recall. To test the hypotheses that the meal-recall effect would be weaker for people with low episodic memory ability compared to those with high ability, and stronger in those in the guided-recall condition than the unguided condition, a repeated-measures ANOVA was conducted, with grams of biscuits consumed after each recall-day (today vs. yesterday) as the dependent variable and memory group and the level of guidance as the independent variables. There was an interaction between recall-day and level of guidance, $F(1,33) = 12.88$, $p = .001$, $\eta_p^2 = 0.281$. It has already been reported that participants in the unguided-recall condition consumed significantly fewer biscuits when recalling today's meal, compared to yesterday's meal (see section 3.2.1). Participants in the guided condition ate more biscuits after recalling today's meal ($M = 82.19$, $SD = 40.36$), compared to recalling yesterday's meal ($M = 74.24$, $SD = 46.25$), $F(1,20) = 7.31$, $p = .014$, $\eta_p^2 = 0.268$ (see Fig. 1). There was no evidence of an interaction between recall-day and memory group, $F(1,33) = 1.11$, $p = .299$. Low and high memory participants consumed a similar amount of biscuits after recalling today's and yesterday's meal (low memory, today's lunch: $M = 62.00$, $SD = 43.32$; yesterday's lunch: $M = 64.28$, $SD = 38.07$; high memory, today's lunch: $M = 77.42$, $SD = 43.21$; yesterday's lunch: $M = 74.11$, $SD = 44.69$). There was no evidence of a recall-day x memory group x level of guidance interaction, $F(1,33) = 0.15$, $p = .700$.

3.2.3.2. Verbal-recall. A repeated-measures ANOVA found no evidence of a meal-recall effect, $F(1,36) = 0.02$, $p = .880$. There was also no evidence of a recall-day x level of guidance interaction, $F(1,36) = 0.06$, $p = .801$. Unguided and guided participants ate a similar amount of biscuits after recalling today's and yesterday's lunch (unguided, today's lunch: $M = 77.20$, $SD = 35.08$; yesterday's lunch: $M = 76.90$, $SD = 32.00$; guided, today's lunch: $M = 48.45$, $SD = 27.67$; yesterday's lunch: $M = 49.65$, $SD = 27.38$). The recall-day x memory group interaction was not significant, $F(1,36) = 2.80$, $p = .103$ (low memory, today's lunch: $M = 61.70$, $SD = 40.44$; yesterday's lunch: $M = 57.20$, $SD = 36.82$; high memory, today's lunch: $M = 63.95$, $SD = 28.17$; yesterday's lunch: $M = 69.35$, $SD = 26.98$), or a recall-day x level of guidance x memory group interaction, $F(1,36) = 0.21$, $p = .651$. The meal-recall effect was not elicited in any of the groups in the verbal recall condition (see Fig. 1).

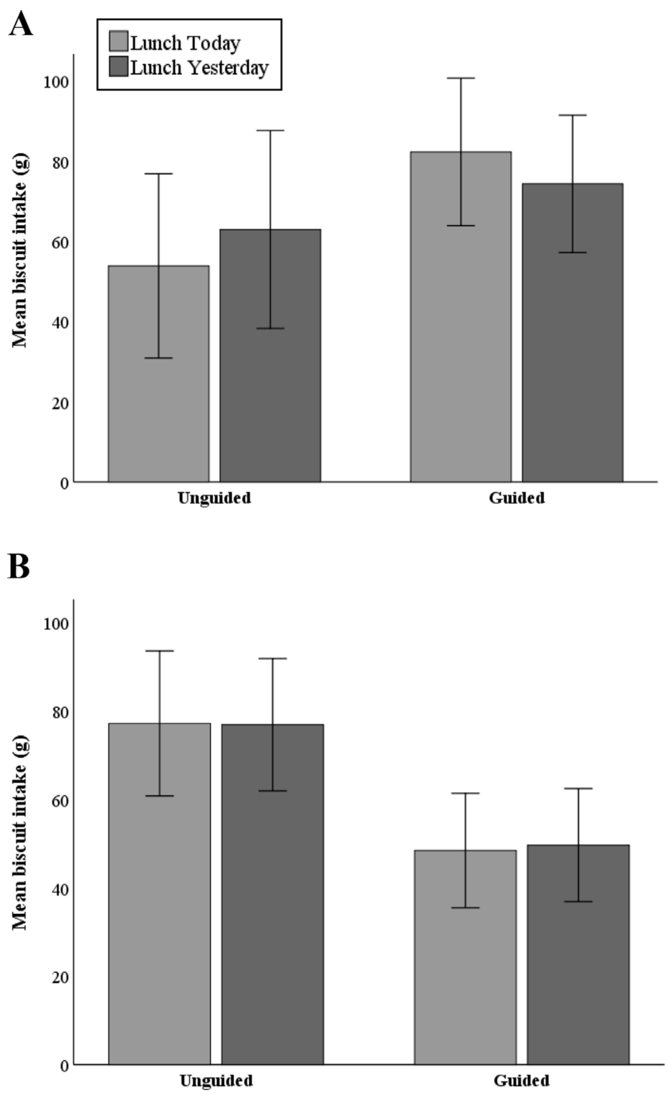

Fig. 1. Mean biscuit intake (g) for the unguided and guided groups, as a function of condition (today's or yesterday's lunch recalled) for A) written mode of recall and B) verbal mode of recall. Error bars represent 95% CI.

3.3. Post-hoc exploratory analyses

Four covariates were examined, to explore whether the meal-recall effect was modulated by any one of them. Subjective hunger ratings recorded before and after recalling today's and yesterday's meals, but there were no significant pre-post recall changes in either the written-recall group (today's meal: $p = .378$; yesterday's meal: $p = .461$), or the verbal-recall group (today's meal: $p = .701$; yesterday's meal: $p = .404$). For the written-recall group, neither TFEQ disinhibition scores, nor DEBQ restraint scores were a significant covariate in the model, $F(1,32) = 0.41$, $p = .526$ and $F(1,32) = 0.19$, $p = .665$, respectively. Similarly, for the verbal-recall group neither the TFEQ disinhibition, nor DEBQ restraint scores were a significant covariate, $F(1,35) = 0.87$, $p = .359$ and $F(1,35) = 0.18$, $p = .675$, respectively. Next, VVIQ score was added as a covariate to the model, but it was not significant (written-recall: $p = .443$; verbal-recall: $p = .297$).

4. Discussion

This study replicated the previous finding that written, unguided recall of an earlier meal, immediately before a snacking session, significantly reduced biscuit intake compared to recalling a meal from the previous day (Higgs, 2002; Higgs, Williamson, & Attwood, 2008). However, the meal-recall effect was not robust to changes in the protocol and was not observed when we changed the mode of recall to verbal or when guidance was provided to elicit more detailed recall. It was observed that in the written-recall group, participants who were unguided in their meal-memories showed the meal-recall effect (i.e. ate fewer biscuits after recalling today's lunch, compared to yesterday's lunch), but guided participants showed a *reversal* of this effect (i.e. ate *more* biscuits after recalling today's lunch, compared to yesterday's lunch). Participants in the verbal-recall group did not seem to display the meal-recall effect in either the unguided or the guided condition. Contrary to the initial hypotheses, episodic memory ability had no influence on the meal-recall effect and varying the level of guidance did not differentially affect low and high memory participants. We also found no evidence that a shift in subjective hunger levels, disinhibition, dietary restraint or visual imagery ability moderate the relationship between meal-memories and subsequent intake.

4.1. Level of guidance

Asking participants to recall a recent meal before a snacking session in the written-recall, unguided condition resulted in subsequent biscuit intake decreasing by about 9 g – a 14% reduction in overall intake (medium effect-size, $d_z = 0.62$). Given that the biscuits served during the experiment had a high energy content (499 kcal per 100 g on average), this decrease in consumption translated into a meaningful reduction in energy intake (about 70 calories). This finding is consistent with previous studies which also demonstrated the meal-recall effect (Higgs, 2002; Higgs, Williamson, Rotshtein, & Humphreys, 2008). For example, asking people to recall today's lunch resulted in almost a 15 g decrease in biscuit intake (−21%; large effect-size, $d = 2.70$), when compared to the intake of those who were asked to think about anything else they wanted (Higgs, 2002; experiment 1). Even higher reduction values were observed in experiment 2, in which recalling today's lunch decreased intake by about 23 g (−49%; large effect-size, $d = 1.57$), when compared to intake of those who recalled yesterday's lunch. Thus, the present experiment was able to replicate the findings of Higgs (2002), albeit the observed effect-size was smaller than ones observed in previous experiments and the intake reduction rates varied across experiments.

In contrast to the unguided-recall group, snack intake of participants who were in the written-recall, guided group, increased by approximately 8 g after they recalled a meal they consumed on the same day, relative to when they recalled a meal from the previous day. This pattern of data is completely opposite to that observed in the equivalent unguided group, and contrasts with both previous literature and our initial hypotheses. Theoretically, this could have been because being prompted for more details regarding an eating episode could have shifted focus away from remembering the *consumption* episode and diverted it to thinking about *food items* instead.

This is significant, because on the one hand, literature suggests that recalling a past meal decreases subsequent snacking (Higgs, 2002; Higgs, Williamson, & Attwood, 2008) and on the other hand there is literature to suggest that thinking about food stimulates appetite. For example, Fedoroff, Polivy, and Herman (1997) showed that people ate more pizza after they were instructed to think about that food for 10 min. This disparity in literature findings might be because thinking about *food* is not the same as thinking about *consumption*. Recalling a recent and specific eating event might re-activate any satiety signals that were associated with it, and this might lead to suppressed consumption. However, simply bringing food to mind might stimulate appetite and lead to increased intake. The idea that thinking about eating may inhibit consumption, but thinking about food may promote it is supported by finding from Morewedge & Vosgerau (2010). They found that when participants imagined eating 30 sweets, they subsequently ate fewer sweets, but when they imagined handling 30 sweets (but not eating them), participants subsequently ate *more* sweets.

4.2. Mode of recall

It was initially hypothesised that no differences between written and verbal-recalls would be observed, however present results suggest the mode of meal-memory recall made a significant difference to the pattern of changes in snacking. Specifically, whereas the within-subjects manipulation (day of recall) produced an effect in the written group, the verbal group did not show an effect at all. These findings prompt an obvious question – why did the verbal and written groups differ so significantly?

One possibility is that mode of recall may have impacted on the nature of the memory being recalled. While the literature on the impact of mode of recall on the quality of memory is mixed, there is some suggestion that verbal reports produce more detailed, more accurate reports of complex texts or visual experiences and more detailed responses to follow up questions (Bekerian & Dennett, 1990; Kellogg, 2007; Sauerland & Sporer, 2011) Indeed, in this study the verbal-recall group produced more internal details, particularly in the guided condition, than the written recall group, which may suggest a better-quality memory experience. If the meal-recency effect is driven by a difference in the quality of memory representation after a 3hr compared with a 27hr delay, then it is possible that sufficiently higher quality memories in the verbal recall group would reduce this difference, leading to little differential effect of the different meal recencies. One counter argument to this explanation is that those in the written-recall unguided group ate over 20 g less than those in the verbal recall unguided group. If the verbal recall group were producing generally better memories, one would expect amount eaten to be generally lower in this group.

Another possible explanation is that because participants in the verbal group were interviewed by the experimenter (instead of responding to questions on the computer), the meal-recall effect was disrupted in some way. The today/yesterday manipulation had no effect on snacking in the verbal group, but it had a profound effect on snacking in the written group. The exact mechanism behind this occurrence is unclear at the moment, but it is possible that talking to the experimenter distracted attention away from the process of remembering a meal, and this could have impacted any subsequent assessment of current metabolic need (similarly to Collins & Stafford, 2015), suggesting why intake was comparable irrespective of the day being recalled in the verbal groups.

4.3. Memory ability

Somewhat surprisingly, episodic memory ability did not seem related to magnitude of the meal-recall effect. It is possible that present results were observed because memory ability is not related to the meal-recall effect, but it is also plausible to suspect that the kind of memory assessed by the THT does not translate into individual differences in meal-memory quality. It has previously been found that performance on different tasks designed to measure episodic memory produced very different estimates of memory ability (Cheke & Clayton, 2013), and therefore the THT might not measure differences in the kind of memory which modulates the meal-recall effect. For example, it may be that the memory skill required to remember complex item-location-time combination is quite different to that required to induce the meal-recall effect, which may be more focused on memory for internal feelings and sensations. Future research should thus investigate individual differences in memory ability that predict accuracy and vividness of meal memories, and how these impact on the meal-recall effect.

4.4. Disinhibition and restraint

Higgs et al. (2008) found that those who scored highly (> 8) on the disinhibition sub-scale of TFEQ did not show the meal-recall effect. However, the data collected in this experiment did not seem to support this finding: A significant reduction in snacking following recent meal-recall was observed in the written-recall, unguided group (analogous to the method employed by Higgs et al., 2008), despite more than 30% of the participants in this group scoring more than 8 on the disinhibition factor. In fact, the meal-recall effect did not seem to be affected by disinhibition in any of the experimental groups, despite an average of 30% of disinhibition scores being greater than 8. There was also no impact of dietary restraint, which is in line with previous findings (Higgs et al., 2008). This implies that in the right circumstances, episodic recollections may be used to suppress eating regardless of individual differences in eating behaviour profile.

4.5. Strengths and limitations

Previous research on the meal-recall effect has been conducted using relatively restricted samples, limited to unrestrained female undergraduate students (Higgs, 2002); Collins & Stafford, 2015), or young, lean students (Higgs et al., 2008). The present study was conducted in participants aged 20 to 73, who had BMIs ranging from 17 to 31. Participants were not pre-selected based on their restraint or disinhibition scores and were actively recruited from typically non-student environments.

Although the present study implemented a number of recommendations to increase its validity and reliability (Robinson, Bevelander, Field, & Jones, 2018), it is not free from methodological limitations. Despite a power analysis being carried out before data collection, tests of additional manipulations could have been underpowered, and a greater sample size is required in order to conduct more powerful statistical analyses. Furthermore, the number of episodic details was used as a proxy for vividness in the present study, but more episodic details do not necessarily translate into greater memory vividness (Brewin & Langley, 2019; Kensinger et al., 2011). Future studies would benefit from including both objective (e.g. number of episodic details) and subjective (e.g. a rating scale) measures of meal-memory vividness. This is also linked to the fact that the accuracy of meal memories reported could not be verified, and so it is unclear whether distorted or inaccurate meal memories would have affected the results.

5. Conclusion

In this study we replicated the finding by Higgs and colleagues that people will snack less after recalling a meal they ate earlier today than after recalling a meal they ate the day before, although the observed effect size was somewhat smaller than the ones observed in Higgs (2002). Moreover, we only replicated the effect when methods were matched to the previous studies (i.e. when meal-recall is written and unguided). The effect did not generalise to different methods of recall and in contrast to our hypotheses, individual differences in memory ability did not moderate the meal-recall effect. Findings highlight the importance of contextual factors in moderating the meal-recall effect and suggest further large studies are required better understand these and associated mechanisms of action.

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