Feeling Happy And Thinking About Food: Counteractive Effects Of Mood And Memory On Food Consumption

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Abstract

Separate lines of research have demonstrated the role of mood and memory in the amount of food we consume. However, no work has examined these factors in a single study and given their combined effects beyond food research, this would seem important. In this study, the interactive effect of these factors was investigated. Unrestrained female participants (n = 64), were randomly assigned to either a positive or neutral mood induction, and were subject to a lunch cue (recalling their previously eaten meal) or no lunch cue, followed by a snack taste/intake test. We found that in line with prediction that food intake was lower in the lunch cue versus no cue condition and in contrast, food intake was higher in the positive versus neutral mood condition. We also found that more food was consumed in the lunch cue/positive mood compared to lunch cue/neutral mood condition. This suggests that positive mood places additional demands on attentional resources and thereby reduces the inhibitory effect of memory on food consumption. These findings confirm that memory cue and positive mood exert opposing effects on food consumption and highlight the importance of both factors in weight control interventions.

Keywords: Mood, Memory, Unrestrained, Consumption, Food Intake, Limited Capacity Hypothesis

1.0 Introduction

The importance of memory in regulating how much food we consume has gained prominence in recent years. The background to this is centred on the role of the hippocampus and case studies from neuropsychology. It is well known that the hippocampus plays a central role in learning and memory (Vargha-Khadem et al., 1997), with interestingly, more recent evidence suggesting greater involvement in certain types of memory; episodic more than semantic (Steinvorth et al., 2005). The emphasis on episodic memory helps in understanding how impairments to the hippocampus might influence eating behaviour. For instance, it was found that densely amnesic patients with hippocampal damage (Hebden, 1985; Rozin et al., 1998), consumed multiple meals, having no explicit memory of what was eaten previously. This led to the proposal that at least under certain circumstances, memory of eating and the current eating situation are more predictive of consumption than physiological signals. In support of this, it was emphasized that across both studies (Hebden, 1985; Rozin et al., 1998), all three patients had different but overlapping brain damage; but what they all shared was a dense amnesic syndrome and extremely poor/no memory for recently eaten meals. Further, since there was no evidence of damage to the hypothalamic structures, this therefore suggested that their inability to sense when to discontinue eating could not be attributed to accessory damage to food-regulation structures.

To understand the role of memory in neurologically intact populations, Higgs (2002) assigned healthy volunteers to either a ‘lunch cue’ (required to explicitly recall the lunch they had eaten that day) or a ‘no cue’ (free thought) condition followed by a taste test. Findings revealed that the explicit recall of lunch had an inhibitory effect on the participants’ intake of snack foods. It was concluded that this reduction in intake was likely due to remembering what had been eaten triggering beliefs about the satiating effects of that food. The follow up study which compared the effect of remembering lunch eaten the previous to the current day, confirmed that the effect was limited to memory for food eaten that day (Higgs 2002).

In addition to memory influencing eating behaviour, another important factor is mood. It is widely accepted that human eating behaviour changes according to changes in emotional state, for example experiencing sadness or happiness (Canetti, Bachar & Berry, 2002). Patel and Schlundt (2001) found that individuals in a positive and negative mood consumed significantly higher amounts of calories from fat, protein and carbohydrate at meal times than individuals in a neutral mood. However, as Canetti et al. (2002) pointed out, the relation between emotion and eating differs according to the particular characteristics of the individual and their specific emotional states. For instance, Schotte, Cools and McNally (1990) and Baucom and Aiken (1981) discovered that individuals who were dieting ate more when depressed than non depressed dieters. In food related research, individuals are often characterized according to level of 'restraint' and separately 'disinhibition'. Restrained individuals are those adopting a high level of dietary restraint due to worries about body image and weight (Bryant, King, Kiezerbrink & Blundell, 2008). Those categorized as disinhibited eaters are more likely to consume food opportunistically, e.g. being especially responsive to the palatability of food and other people eating with them (Bryan et al., 2008).

The relationship between negative emotions and eating behaviour has been widely studied and numerous studies are in agreement with the notion that negative affect decreases food intake in unrestrained eaters (Polivy & Herman, 1976; Sheppard-Sawyer, McNally & Fischer, 2000). However, there has been little experimental investigation into the effects of positive mood on an individual's consumption of food. Macht (2008) proposed that positive mood has an identical effect as negative mood on food intake in restrained eaters because all intense emotions impair cognitive eating controls. This is consistent with the limited capacity hypothesis proposed by Boon, Stroebe, Schut and Jansen (1998), which claims that restrained eaters' cognitive capacity to maintain restricted food intake is limited by distraction. Although that theory has mostly been applied to restrained eaters (e.g. Lattimore & Maxwell, 2004), since work has also found that distraction led to higher food consumption in unrestrained individuals (Boon et al., 2002), suggests that cognitive resources involved in controlling intake are limited in both restrained and unrestrained individuals. This is also underlined by one study that used different film extracts to manipulate mood state (Yeomans & Coughlan 2009) and found that individuals low in restraint (and high disinhibition) ate more in the positive affect condition than the negative and neutral condition. Therefore, being in a positive mood state may have acted as a distraction to these unrestrained individuals and thus demanded mental resources also used to control food intake; since such resources are limited, the consequence is that less capacity is available to monitor intake, resulting in higher consumption. The fact the effect was unique to positive mood could also be linked to the suggestion that when an individual is in a positive rather than a negative or neutral mood, the act of eating food has a greater effect on elevating mood (Macht et al., 2004). In other words, exposure to snack foods in the positive affect condition increased 'hedonic hunger'; that is eating to gain a pleasurable experience, and so resulted in increased intake.

Whilst research has examined the effect of memory cues (Higgs, 2002) and mood (Yeomans & Coughlan, 2009) separately, no work has looked at these factors together. This is important to explore for a number of reasons. Firstly, since it is clearly the case that natural episodes of eating take place in the presence of both mood and cognition; hence studying these factors separately tells us little about everyday food consumption. This being the case, the potential to inform therapies aimed at reducing weight gain is much better served by studies including both of these core factors which can also measure the magnitude of their separate effects on food intake. Secondly, there are separate lines of research that predict an interaction of mood and memory's effect on food intake. Increases in positive mood have been suggested to increase dopamine activity in key areas of the brain involved in emotion and cognition, including the hippocampus, amygdala and prefrontal cortex (Ashby et al., 1999). It has been theorized that these alterations, which can be triggered by positive mood induction, are responsible for improvements in cognitive performance (Ashby et al., 1999; Mitchell & Phillips, 2007). However, it is further speculated that the extent to which increased dopamine activity benefits cognition follows an inverted-U shape (Mitchell & Phillips, 2007). This might also help explain why positive mood induction has been shown to improve performance in certain types of tasks such as creativity, whereas actually impair performance on tasks requiring more focussed attention, such as alternating Stroop tasks and memory (Phillips et al., 2002; Siebert et al., 1991; Stafford et al., 2010). For instance, in one of those studies, free recall was lower for those individuals in the positive versus neutral mood induction (Stafford et al., 2010). It is therefore theorized in the present study, that induction into a positive mood state would act to reduce attentional focus and thereby also impair memory's ability to access previous eating episodes. As a consequence, it is predicted that positive mood will reduce the inhibitory effects of memory (lunch cue) on food consumption.

In the present study, unrestrained female eaters consumed a standard (provided) lunch and later the same day completed a snack taste/intake test in one of four conditions; induced into either a neutral or positive mood and then exposed to either a "lunch cue" or "no cue" condition. The rationale for using only unrestrained consumers was to focus more on the effects on those not actively dieting and consistent with previous work (Higgs, 2002). We predict that on the basis of previous research (Higgs, 2002; Yeomans & Coughlan, 2009) that individuals in the lunch cue versus no cue condition would consume less food in the snack taste/intake test, whilst those in the positive versus neutral mood induction will consume more food. On the premise of limited capacity theory (Boon et al., 1998) and the deleterious effects of positive mood on memory (Stafford et al., 2010), we further expect an interaction of these two factors; where we tentatively predict more food will be consumed in the lunch cue/positive mood compared to lunch cue/neutral mood condition.

2.0 Methods

2.1 Participants

Participants were 69 females, age ranging from 18-23, (M = 20.33, SD = 1.29) comprising of undergraduate students and non-students recruited locally (Table 1). Participants were excluded on the basis of whether they had any food allergies; if they were currently dieting or had experienced any problems with their eating. Potential participants were informed that the study was examining the factors that influence taste. Participants were not paid but the lunch provided was free. The University of Portsmouth Ethics Committee approved the study protocol.

-Insert Table 1 About Here-

2.2 Design

The study used a 2 x 2 independent groups factorial design. Participants were randomly allocated to conditions. The independent variables were Mood Induction: MI-P (positive mood) or MI-N (neutral mood) and Memory Cue: LC (lunch cue) or NC (no cue). In the LC condition participants were required to explicitly recall their lunch, whereas NC was a free thought exercise. The dependent variables were the amount of food (grams) consumed by the participants at the end of testing. Additionally, their "hunger", "fullness" and "desire to eat" measures at the beginning and end of testing, "liking" and "choice" of food measures and positive and negative affect scores.

2.3Materials

2.3.1 Food Snacks

The participant's lunch comprised of a sandwich of their choice from 4 sandwiches from the Co-operative supermarket (Portsmouth) including; chicken southern fried wrap (204g, 415kcal), ham and cheese (176g, 415kcal), egg mayonnaise (144g, 360 kcal), and chicken salad (197g, 310kcal). All participants were given a packet of crisps (Walkers, 35g, 131 kcal) and squares of flapjack bites (Waitrose Ltd, 22 g, 60 kcal). For the snack taste and intake test, participants were given three types of food products: Co-operative custard creams (per biscuit: 12g, 60 kcal), Co-operative double chocolate chip cookies (per biscuit: 11g, 55 kcal) and McVitie's Mini Cheddars (1.25g, 8 kcal).

2.3.2 Mood Induction

The study used two pieces of classical music: 'Eine Kleine Nachtmusik' (Mozart) for positive mood induction and 'The Planets op.32 Venus' (Holst) for neutral mood induction. These pieces were selected due to the findings of Mitterschiffthaler, Fu, Dalton, Andrew and Williams (2007) that 'Eine Kleine Nachtmusik' induced participants into a happy mood and 'The Planets op.32 Venus' induced participants into a neutral mood; both in terms of self reports of emotional state and fMRI data. We used music as the method of mood induction for a number of reasons: Firstly, it has proven a reliable method in our previous research (Stafford et al., 2010) and that of others (see review: Gerrards-Hesse, Spies, & Hesse, 1994). Secondly, it has advantages over other methods that rely on asking participants to recall positive events (i.e. Velten procedure), as such methods carry an increased risk of demand characteristics. Finally, since we were already using a video during the snack taste/intake test (see 2.3.3), it seemed prudent to use a different modality for mood induction.

2.3.3 Film

A video of the 'Blue Planet: a natural history of the oceans (episode 2 "The Deep", BBC 2001)' was used whilst participants completed the taste test. This procedure is similar to Yeomans and Coughlan (2009) and was implemented so that participant would feel more relaxed and less aware of the amount they were eating. The music and video were played on an RM desktop computer through stereo HD-3030 headphones via iTunes.

2.3.4 Dietary Restraint

Restraint was determined using the restraint sub-scale of the Dutch Eating Behaviour Questionnaire (Van Strien, Frijters, Bergers, & Defares, 1986). This entailed participants to rate their agreement to ten questions by ticking a box on a 5-point likert scale from never (1) to very often (5). The minimum and maximum values a participant could score are 1 and 5. In line with Higgs (2002), participants with scores of 2.2 or less were classified as unrestrained eaters ($n = 64$) Participants with a score greater than 2.2 were classified as restrained eaters and their data ($n = 5$) not included in the analysis.

2.3.5 Mood Measure

The PANAS (Positive and Negative Affect Schedule) questionnaire (Watson, Clark, & Tellegen, 1988) was used to determine the mood of the participant. Participants rated their agreement on a 5-point likert scale from 'very slightly or not at all' (1) to extremely (5) for each of 20 items. The minimum and maximum values a participant could score are 10 (low negative or positive mood) and 50 (high negative or positive mood).

2.3.6 Hunger Ratings

Visual Analogue Scales (VAS) were used to assess the participants' hunger including how hungry they felt, their fullness and desire to eat, and their taste ratings of the test food including their liking and choice. These were derived from Higgs (2002). The participant had to place a vertical line on the horizontal line at the point at which they felt they agreed with the item.

The VAS for hunger, fullness and desire to eat were anchored by 'not at all' and 'extremely' on a 100-mm line. The VAS for liking and preference of food were anchored by 'never choose' and 'always choose' for choice, and 'not at all' and 'extremely' for liking on a 100-mm line.

2.4 Procedure

Participants were told that they would be participating in a study into factors that influence taste and it would involve tasting and giving opinions on various foods. Once participation was confirmed, individuals were allocated a time slot and date to take part in the study and were informed to eat a standard breakfast on that day. For the first part of the study, testing commenced at 12:00 P.M. On arrival, participants were asked to provide written informed consent. They were provided with a lunch and instructed to eat as much as they desired until they felt full. Upon finishing the lunch, the participant was asked to return for the second part of the study at the time they were given (always same day) and to refrain from eating or drinking anything other than water before this time. Participants were given time slots that were at least 2 h after the first part of the study.

In the second session, participants completed the PANAS questionnaire (Watson et al., 1988), followed by the Dutch Eating Behaviour Questionnaire (Van Strien et al., 1986) and the VAS measuring hunger. The participant was then exposed to the LC or NC condition, followed by the MI-P or MI-N, with test order counterbalanced. In the LC condition, participants were asked to think about the lunch they had eaten that day and to write their thoughts on a piece of paper. For those in the NC, they were given free choice to think about something and write down their thoughts; These were the same instructions as the previous study (Higgs, 2002). In both mood inductions, participants were required to listen to music for 8 minutes. Post mood induction, participants were asked to complete the PANAS questionnaire again; this was in order to assess whether the mood induction had been successful. The participant was then exposed to the snack taste and intake test. For this, they were presented with three plates, each containing equal amounts (15 biscuits) of the three snacks, clearly labelled 'A', 'B' and 'C'. They were advised to taste each of the snacks and rate them for liking and choice using the VAS provided, whilst watching a 12 minute excerpt of the 'Blue Planet'. The participant was further informed that they could eat as much as they wished as there was an unlimited supply (similar to Higgs, 2002). The VAS measuring "hunger", "fullness" and "desire to eat" was then completed. Finally, participants were given a debriefing and asked to refrain from revealing the purpose of the investigation to others. Intake was calculated by measuring the difference in weight of the food products at the end compared to the start of the test session. The experiment lasted approximately 40 minutes.

2.5 Data Analysis

From the PANAS data we examined the positive mood scores only, as this was the main focus in terms of mood manipulation. Initial data screening revealed two participants in the positive mood group whose mood scores were more than 2SD from the mean (at baseline and post mood induction) and since mood induction was a central part of this study, their data were excluded. The mood data for the remaining participants were subjected to a repeated measures ANOVA using the within subject factor of Time (before or after) and the between subjects factor of Mood induction (MI-P/MI-N). The purpose of analyzing mood was to check for any baseline differences in positive mood, and that positive mood increased in the positive (MI-P) condition but not in the neutral MI-N condition. The scores for hunger, fullness and desire to eat were entered into separate repeated measures ANOVA's using the within subject factor of time (baseline or end of study) and the between subjects factors of mood (MI-P/MI-N) and memory (LC/NC). The "liking" and "choice" scores for the taste test and the amount of food consumed was subjected to a univariate ANOVA using the between subjects factors of mood (MI-P/MI-N) and memory (LC/NC). Bonferroni comparisons were carried out on any significant effects.

3.0 Results

3.1 Mood Manipulation

For the positive affect scores, there were main effects of Time, $F(1, 60) = 83.50$, $p < .001$, $n^2 = .58$, and Mood, $F(1, 60) = 13.97$, $p < .001$, $n^2 = .19$, which were qualified by a Time x Mood interaction, $F(1, 60) = 87.81$, $p < .001$, $n^2 = .59$. Further analyses verified there were no differences in mood between the MI-P and MI-N groups at pre-induction ($p = .98$).

In contrast and consistent with expectation, positive mood increased in the MI-P group ($p < .001$) from pre to post-induction, but not for those in the MI-N group ($p = .87$) (Table 2).

-Insert Table 2 About Here-

3.2 Food Intake

Analysis revealed main effects of Mood, $F(1, 58) = 26.23$, $p < .001$, $n^2 = .31$, and Memory cue, $F(1, 58) = 93.55$, $p < .001$, $n^2 = .61$, where consistent with prediction more food was consumed in the MI-P versus MI-N condition plus more consumed in the NC compared to LC condition. The effect sizes further demonstrate that the magnitude of the Memory cue effect was roughly twice that of Mood. Additionally, these effects were qualified by a Mood x Memory interaction, $F(1, 58) = 4.30$, $p = .04$, $n^2 = .07$, with pairwise comparisons revealing all effects were significant. Consistent with our prediction, more food was consumed in the lunch cue/positive mood versus lunch cue/neutral mood condition (Figure 1).

-Insert Figure 1 About Here-

3.3 Questionnaire Measures

For food liking, analysis revealed main effects of Memory, $F(1, 58) = 15.60$, $p < .001$, $n^2 = .21$, where liking was lower in the LC ($M = 64.2$, $SE = 1.6$) compared to NC ($M = 73.8$, $SE = 1.7$) condition. Significant main effects of Time were found for Hunger, desire to eat, and fullness, which decreased from baseline to end of study for the former two measures, but increased for the latter (Table 3). No other effects were significant.

-Insert Table 3 About Here-

3.4 Correlations

To further understand the relationship between food intake, liking and mood, we computed a change of positive mood variable by subtracting the pre-induction scores from the post-mood induction scores, with higher resulting scores indicative of increases in positive mood. We then completed separate correlations for those groups who received the memory cue and those that did not.

For the LC groups only, this revealed a significant association between positive mood and food intake, $r(32) = 0.43$, $p = .01$, suggesting that increases in positive mood are associated with higher food consumption; this therefore implies that one of the mechanisms by which lunch cueing exerts lower food intake is via its relationship with changes in mood.

4.0 Discussion

The study found that less food was consumed when individuals were cued to recall their lunch compared to a no cue control. This finding is consistent with prediction and previous work (Higgs, 2002). The finding that food liking ratings were lower in the lunch cue versus no cue condition was interesting and offers a possible explanation of why less food was consumed. Though no differences were found in that previous study (Higgs 2002), the values for liking of the snacks were similar to the current study; [Higgs 2002: M = 63.0 (LC); M = 71.0 (NC)] compared to the study here [M = 64.2 (LC); M = 73.8 (NC]). It therefore seems possible that had a larger sample been used in that work (Higgs 2002, sample was n=10 per condition), that differences in liking would also have been detected. Reflecting on why recalling a recently eaten meal might decrease liking for a later snack is not clear. It is possible that if the meal eaten previously was preferred more to the current snack on offer, that a negative contrast ensued, thus explaining the effects. Such an explanation is consistent with a study where exposure to palatable food led to lower subsequent food intake (Rogers & Hill, 1989). It is also worth noting that in the previous study (Higgs, 2002), all individuals were asked to eat a slice of pizza for their lunch, whereas in the present study, participants were given a choice of sandwich. Since individuals *chose* their food in our study and thus in a sense their lunch was preferred over the other choices, it is feasible that for some, the snacks in the taste test (not chosen) were not as preferable as their lunch meal. Since that original study (Higgs, 2002), work has shown that memory's inhibitory effect on food intake is not limited to being cued at the time of eating. For instance, focusing on sensory aspects of food at lunchtime led to lower later snack consumption compared to reading a food related article or a control condition (Higgs et al., 2011). Additionally, overall vividness of memory for lunch was predictive of lower intake of food. Hence, by linking ratings of the strength of the memory for the previously eaten lunch, the researchers were able to infer that the clarity of that memory is associated with reduced snack consumption.

The finding that more food was consumed for those in the positive versus neutral mood induction is consistent with our prediction and previous work (Yeomans & Coughlan 2009). However, any discussion of mood effects on food must be considered from the wider perspective of individual characteristics. For individuals in the positive mood induction, that study found higher snack intake in the low restraint/high disinhibition group but not the low restraint/low disinhibition group. Individuals high in disinhibition would be more inclined to the over consumption of food and at more extreme levels with binge eating (Bryant, King & Blundell, 2008; d'Amore et al., 2001). It has been theorized that these individuals are more susceptible to highly calorific food (as in test snack food), and that positive mood induction acts to increase hedonic hunger (Yeomans & Coughlan 2009). To some extent, this dichotomy of low/high disinhibition is consistent with a study that found that following a positive mood induction, food intake increased for those categorized as uncontrolled (similar to high disinhibition), but actually decreased for controlled eaters (Turner, Luszczynska, Warner, & Schwarzer, 2010). Although we did not measure disinhibition or uncontrolled eating tendencies in the present study, given the similarity in the results between the three studies, it would seem likely that the majority of participants in our study were also high in these measures. Reflecting more widely on mood and food, the aspect of mood regulation is also relevant here. Hence, individuals in a positive mood might well wish to maintain their mood state and one avenue for this endeavor is to consume highly calorific food that they are naturally drawn toward. In contrast, one could imagine that for those more inclined toward controlled eating regimes (low disinhibition), that the maintenance of a positive mood state lies in the tighter regulation and possible reduction of such foods.

One of the strengths of the present study was to examine both memory and mood in a single study, allowing us to assess the relative strength of these factors. This revealed that the effect of memory on food intake was substantially larger than that of mood. This is a potentially important finding, in that it suggests any intervention strategies for those wishing to lose weight might well be more effective if they concentrated on memory rather than mood manipulations. Indeed, one study has already reported that a smart phone application that emphasizes the importance of attending to the previously eaten meal has shown success in reducing weight (Robinson et al., 2013). Of course, in broader aspects of diet and health, appreciating the bi-directional aspects of mood and food are essential, as evidence by a recent diary study where consumption of healthy foods (fruit, vegetables) elevated positive mood (White, Horwath, & Conner, 2013). The present work also found that although less food was consumed in the lunch cue versus no cue condition, that positive mood acted to reduce this effect. Hence for those in the lunch cue/positive mood condition, more food was consumed compared to those in the lunch cue/neutral mood condition. Theoretically, these findings provide support for Boon et al.'s (1998) limited capacity hypothesis which proposes that control of food intake is particularly demanding in restrained eaters, so that any additional distraction competes for these scarce mental resources. Applied to the present study, as positive emotional stimuli requires greater attention, those in this condition would be expected to have a reduced cognitive capacity. As a consequence, less mental resources were available for recalling their previously eaten meal, thereby reducing the inhibitory effect of memory on food intake. Since this effect was found for unrestrained individuals is also consistent with the previous finding (Boon et al., 2002) and suggests that the limited capacity theory for monitoring food intake is relevant to restrained and unrestrained individuals.

In addition to that theory explaining the present findings, beyond the food literature, positive mood has been shown to increase lateral thinking and creativity (Fredrickson, 2003; Ashby et al., 1999) but also impair completing attentional tasks that specifically required attentional focus and maintaining set (e.g. task switching) and memory (Phillips et al., 2002; Stafford et al., 2010; Seibert & Ellis, 1991). It is this latter function that we presume was impaired in the present study.

We also found that by just examining the lunch cue conditions, that increases in food intake were related to increases in positive mood. This could be taken as additional evidence that positive mood is an important mediator in how memory influences food intake; where increases in positive mood act to reduce the effectiveness of lunch cue. An alternative explanation is that being cued to remember a previously eaten meal influenced mood levels. Since previous work found that vividness of memory for lunch also correlates with food intake (Higgs et al., 2011), future work could compare which of these is the most accurate predictor.

In terms of limitations, since not all of the sandwich snacks used for lunch had the same energy content, it could be argued that this may have contributed to the observed differences in snack intake. However, since the taste test was over 2 hours following lunch, a period in which a substantial amount of the food would have been metabolized, it would seem unlikely to have had a significant impact. Additionally, in a similar previous study that also yielded an effect of lunch cue on food intake, no lunch was provided for participants who therefore may also have consumed lunches of differing energy contents (exp 2, Higgs, 2002). Finally, in the present study, there were no differences between conditions in hunger ratings before the taste test, demonstrating that individuals were at similar levels prior to the intake test. It is nevertheless recommended that future work in this area ensure lunches have the same energy values. Another limitation of the study here is that we did not include a negative mood condition and hence it is uncertain whether similar findings would be found in the positive and negative mood conditions. The rationale to concentrate on positive mood lies in its inhibitory effect on memory and therefore set up our proposed interaction with lunch cue. In contrast, negative mood does not appear to have such a consistent decrement on attentional tasks (Oaksford et al., 1996; Spies et al., 1996; Phillips et al. 2002) and we would therefore expect that it would not lead to an interaction with lunch cue on food intake. Future work should also aim to use a larger sample size than the present study and further recruit male and female participants, as it is uncertain whether the effects observed here would also apply to males. For instance, since research has shown that females are more sensitive to certain properties of music (Nater et al., 2006), it is possible that this might predict stronger effects for females versus males in the current paradigm.

In conclusion, this is the first study to investigate the combined effects of memory and mood on the consumption of food and has revealed that positive mood impairs but does not eliminate the effect of memory on eating behaviour. This phenomenon is explained in terms of Boon et al.'s (1998) limited capacity hypothesis. The expected opposing effects of memory and positive mood on food intake were also observed, additionally revealing that the size of these effects is much greater for memory than mood. Finally, there is a suggestion that at least part of memory's inhibitory effect on food intake is via its association with changes in positive mood.

References

Ashby, F. G., Isen, A. M., & Turken, U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106*(3), 529-550.

Barbano, M. F., & Cador, M. (2005). Various aspects of feeding behavior can be partially dissociated in the rat by the incentive properties of food and the physiological state. *Behavioural Neuroscience, 119(5)*, 1244-1253.

Baucom, D. H., & Aiken, P. A. (1981). Effect of depressed mood on eating among obese and nonobese dieting and nondieting persons. *Journal of Personality and Social Psychology, 41(3)*, 577-585.

Boon, B., Stroebe, W., Schut, H., & Jansen, A. (1998). Food for thought: Cognitive regulation of food intake. *British Journal of Health Psychology, 3(1)*, 27–40.

Boon, B., Stroebe, W., Schut, H., & IJntema, R. (2002). Ironic processes in the eating behaviour of restrained eaters. *British journal of health psychology*, *7*(1), 1-10.

Bower, G. H. (1981). Mood and Memory. *American Psychologist, 36*(2), 129-148.

Bryant, E., King, N., & Blundell, J. (2008). Disinhibition: its effects on appetite and weight regulation. *Obesity Reviews, 9*(5), 409-419.

Bryant, E. J., Kiezerbrink, K., King, N. A., & Blundell, J. E. (2010). Interaction between disinhibition and restraint: Implications for body weight and eating disturbance. *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity*, *15*(1-2), 43-51.

Canetti, L., Bachar, E., & Berry, E. M. (2002). Food and Emotion. *Behavioural Processes, 60(2)*, 157-164.

Collins, A. (2007). UK obesity statistics. Retrieved February 10, 2011, from http://www.annecollins.com/obesity/uk-obesity-statistics.htm

Corkin, S. (2002). Whats new with the amnesic patient H.M? *Nature Reviews Neuroscience, 3*, 153-160.

d'Amore, A., Massignan, C., Montera, P., Moles, A., De Lorenzo, A., & Scucchi, S. (2001). Relationship between dietary restraint, binge eating, and leptin in obese women. *International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity, 25*(3), 373-377.

Drewnowski, A., Krahn, D. D., Demitrack, M. A., Nairn, K., & Gosnell, B. A. (1992). Taste responses and preferences for sweet high-fat foods: evidence for opioid involvement. *Physiology and Behaviour, 51,* 371-379.

Fairburn, C. G., & Hope, R. A. (1988). Changes in behaviour in dementia: a neglected research area. *British Journal of Psychiatry, 152,* 406-407.

Fontaine, K. R., Redden, D. T., Wang, C., Westfall, A. O., & Allison, D. B. (2003). Years of life lost due to obesity. *Journal of American Medical Association, 289(2),* 187-193.

Fredrickson, B. L. (2003). The value of positive emotions - The emerging science of positive psychology in coming to understand why it's good to feel good. *American Scientist, 91*(4), 330-335.

Gerrards-Hesse, A., Spies, K., & Hesse, F. W. (1994). Experimental inductions of emotional states and their effectiveness: A review. *British journal of psychology, 85*(1), 55-78.

Hebben, N., Corkin, S., Eichenbaum, H., & Shedlack, K. (1985). Diminished ability to interpret and report internal states after bilateral medial temporal resection: Case H.M. *Behavioural Neuroscience, 99(6),* 1031-1039.

Herman, C. P., & Polivy, J. (1975).Anxiety, restraint and eating behaviour. *Journal of Abnormal Psychology, 84(6),* 666-672.

Herman, C. P, Roth, D. A., & Polivy, J. (2003). Effects of the presence of others on food intake: a normative interpretation. *Psychological Bulletin, 129(6),* 873-886.

Higgs, S. (2002). Memory for recent eating and its influence on subsequent food intake. *Appetite, 39(2),* 159-166.

Lattimore, P., & Maxwell, L. (2004). Cognitive load, stress, and disinhibited eating. *Eating Behaviors*, *5*(4), 315-324.

Lee, A. Y., & Sternthal, B. (1999). The effects of positive mood on memory. *The Journal of Consumer Research, 26(2),* 115-127.

Lowe, M. R., & Butryn, M. L. (2007). Hedonic hunger: A new dimension of appetite? Physiology and Behavior, 91(4), 432-439.

Macht, M. (2008). How emotions affect eating: A five-way model. *Appetite, 50(1),* 1-11.

Macht, M., Haupt, C., & Salewsky, A. (2004). Emotions and eating in everyday life: application of the experience-sampling method. *Ecology of food and nutrition, 42(4),* 11-21.

Mitchell, R. L. C., & Phillips, L. H. (2007). The psychological, neurochemical and functional neuroanatomical mediators of the effects of positive and negative mood on executive functions. Neuropsychologia, 45(4), 617–629.

Mitterschffthaler, M. T., Fu, C. H. Y., Dalton, J. A., Andrew, C. M., & Williams, S. C. R. (2007). A functional MRI study of happy and sad affective states induced by classical music. *Human Brain Mapping, 28(1),* 1150-1162.

Nater, U. M., Abbruzzese, E., Krebs, M., & Ehlert, U. (2006). Sex differences in emotional and psychophysiological responses to musical stimuli. *International journal of psychophysiology*, *62*(2), 300-308.

NHLBI Obesity Education Initiative. (1998). The Practical guide identification, evaluation, and treatment of overweight and obesity in adults. Retrieved March 25, 2011, from http://www.nhlbi.nih.gov/guidelines/obesity/prctgd_c.pdf.

Oaksford, M., Morris, F., Grainger, B., & Williams, J. M. G. (1996). Mood, reasoning, and central executive processes. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *22*, 477–493.

Patel, K. A., & Schlundt, D. G. (2001). Impacts of mood and social context n eating behaviour. *Appetite, 36(2),* 111-118.

Phillips, L. H., Bull, R., Adams, E., & Fraser, L. (2002). Positive mood and executive function: Evidence from Stroop and fluency tasks. *Emotion*, *2*(1), 12-22.

Phillips, L. H., Smith, L., & Gilhooly, K. J. (2002). The effects of age and induced positive and negative mood on planning. *Emotion*, *2*, 263–272.

Polivy, J., & Herman, C. P. (1976). Clinical depression and weight change: a complex relation. *Journal of Abnormal Psychology, 85(3),* 338-340.

Robinson, E., Higgs, S., Daley, A. J., Jolly, K., Lycett, D., Lewis, A., & Aveyard, P. (2013). Development and feasibility testing of a smart phone based attentive eating intervention. *BMC public health*, *13*(1), 639.

Rogers, P. J., & Hill, A. J. (1989). Breakdown of dietary restraint following mere exposure to food stimuli: Interrelationships between restraint, hunger, salivation, and food intake. *Addictive Behaviours, 14(4),* 387-397.

Rozin, P., Dow, S., Moscovitch, M., & Rajaram, S. (1998). What causes humans to begin and end a meal? A role for memory for what has been eaten, as evidenced by a study of multiple meal eating in amnesic patients. *Psychological Science, 9(5),* 392-396.

Ruderman, A. J. (1985). Restraint, obesity and bulimia. *Behaviour Research and Therapy, 23(2),* 151-156.

Schotte, D. E., Cools, J., & McNally, R. J. (1990). Film-induced negative affect triggers overeating in restrained eaters. *Journal of Abnormal Psychology, 99(3),* 317-320.

Seibert, P. S., & Ellis, H. C. (1991). Irrelevant Thoughts, Emotional Mood States, and Cognitive Task-Performance. *Memory & Cognition, 19*(5), 507-513.

Sheppard-Sawyer, C. L., McNally, R. J., & J. H. (2000). Film-induced sadness as a trigger for disinhibited eating. *International Journal of Eating Disorders, 28(2),* 215-220.

Spies, K., Hesse, F., & Hummitzsch, C. (1996). Mood and capacity in Baddeley's model of human memory. *Zeitschrift für Psychologie mit Zeitschrift für angewandte Psychologie*.

Stafford, L. D., Ng, W., Moore, R. A., & Bard, K. A. (2010). Bolder, happier, smarter: the role of extraversion in positive mood and cognition. *Personality and Individual Differences, 48(7),* 827-832.

Steinvorth, S., Levine, B., & Corkin, S. (2005). Medial temporal lobe structures are needed to re-experience remote autobiographical memories: evidence from HM and WR. *Neuropsychologia*, *43*(4), 479-496.

Tataranni, P. A., Gautier, J., Chen, K., Uecker, A., Bandy, D., Salbe, A. D., Pratley, R. E., Lawson, M., Reiman, E. M., & Ravussin, E. (1999). Neuroanatomical correlates of hunger and satiation in humans using positron emission tomography. *Proceedings of the National Academy of Sciences, 96(8)*, 4569.

Trainor, L. J., & Schmidt, L. A. (2003). Processing emotions produced by music. In I. Peretz & R. J. Zatorre (Eds.), *The cognitive neuroscience of music* (pp. 427-448). Cambridge, Mass: The MIT Press.

Turner, S. A., Luszczynska, A., Warner, L., & Schwarzer, R. (2010). Emotional and uncontrolled eating styles and chocolate chip cookie consumption. A controlled trial of the effects of positive mood enhancement. *Appetite*, *54*(1), 143-149.

Van Strein, T., Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The dutch eating behavior questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International Journal of Eating Disorders*, *5(2*), 295-315.

Vargha-Khadem, F., Gadian, D. G., Watkins, K. E., Connelly, A., Van Paesschen, W., & Mishkin, M. (1997). Differential effects of early hippocampal pathology on episodic and semantic memory. *Science*, *277*(5324), 376-380.

Watson, D., Clark, L. A., & Tellegen, A, (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54(6),* 1063-1070.

Werle, C. O., Wansink, B., & Payne, C. R. (2011). Just thinking about exercise makes me serve more food. Physical activity and calorie compensation. *Appetite, 56(2),* 332-335.

White, B. A., Horwath, C. C., & Conner, T. S. (2013). Many apples a day keep the blues away–Daily experiences of negative and positive affect and food consumption in young adults. *British journal of health psychology*.

Williamson, D. A., White, M. A., York-Crowe, E., & Stewart, T. M. (2004). Cognitive-behavioural theories of eating disorders. *Behaviour Modification, 28(6),* 711-738.

Wooley, S. C., & Wooley, O. W. (1973). Salivation to the sight and thought of food: a new measure of appetite.*Psychosomatic Medicine, 35,* 136-142.

Yeomans, M. R., & Coughlan, E. (2009). Mood-induced eating. Interactive effects of restraint and tendency to overeat. Appetite, 52, 290-298.

Table 1: Mean restraint and age scores for the four groups

	Positive Mood No Memory cue (n=14)		Positive Mood Memory Cue (n=15)		Neutral Mood No Memory Cue (n=16)		Neutral Mood Memory Cue (n=17)		
	M	**SE**	**M**	**SE**	**M**	**SE**	**M**	**SE**	**Group Differences**
Age	20.0	0.3	20.4	0.4	20.2	0.4	20.5	0.2	$p > .70$, NS
Restraint	1.8	0.1	1.8	0.1	1.8	0.1	1.7	0.1	$p > .99$, NS

Table 2 Mean positive mood ratings by group and time (pre/post mood induction)

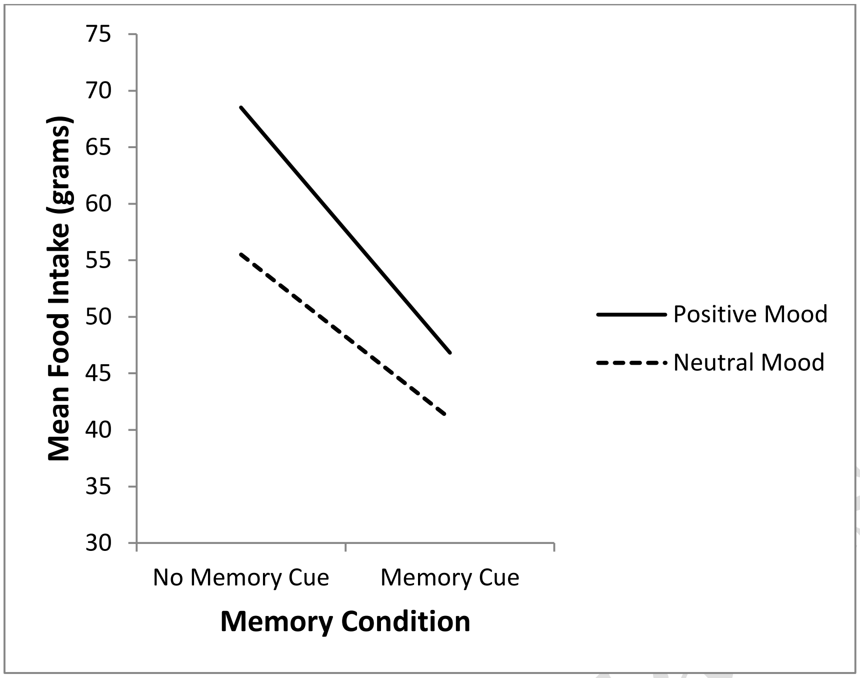
	Positive Mood		Neutral Mood	
	M	**SE**	**M**	**SE**
Pre-induction	41.8	0.55	41.85	0.52
Post-induction	46.65	0.47	41.79	0.44

Table 3: Mean questionnaire ratings by group and time

	Positive Mood No Memory cue				Positive Mood Memory Cue				Neutral Mood No Memory Cue				Neutral Mood Memory Cue			
	Base		End		Base		End		Base		End		Base		End	
	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
Hunger	40.0	3.1	37.8	4.2	43.5	3.1	38.7	2.9	40.0	2.9	29.1	3.6	37.2	2.7	35.4	3.9
Desire to eat	45.7	4.3	40.5	4.2	45.8	4.9	41.8	2.5	47.8	3.2	35.8	3.1	40.0	2.1	37.7	3.0
Fullness	56.2	4.2	62.6	4.5	46.8	4.7	56.6	3.3	49.0	3.4	60.6	3.3	53.7	3.3	60.1	2.7

Legends for figures:

Figure 1 Mean Food Intake By Group (Mood/Memory Cue)



Mean Food Intake (grams)
75
70
65
60
55
50
45
40
35
30
No Memory Cue
Memory Cue
Memory Condition
Positive Mood
Neutral Mood