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Effects of distraction on the development of satiety

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Two experiments explored the hypothesis that distraction causes a reduced sensitivity to the physiological and sensory cues that signal when to terminate a meal. In Experiment 1, eighty-eight females ate five 'Jaffa Cakes' either while distracted by a computer game or while sitting in silence. Analysis of the difference in rated hunger, fullness and desire to eat (pre- to post-intake) revealed that distracted participants experienced smaller changes in their desire to eat and fullness than did non-distracted participants. Experiment 2 assessed whether changes in ratings are attenuated because sensory-specific satiety (or a related process) fails to develop. Using a similar procedure, eighty-four females provided desire to eat, pleasantness and intensity ratings for Jaffa Cakes and for two 'uneaten' foods, both before and at three time-points after consuming five Jaffa Cakes. Non-distracted participants reported a reduction in their desire to eat the eaten food relative to the uneaten food (food-specific satiety), whereas distracted participants maintained a desire to eat all foods. Moreover, this difference between distracted and non-distracted participants was evident 5 and 10 min after the eating episode had terminated. The present findings invite speculation that distraction attenuates the development of sensory-specific satiety, and that this effect persists (at least for a brief period) after the distractor has terminated. More generally, this kind of phenomenon warrants further scrutiny because it holds the potential to contribute towards overeating, either by prolonging an eating episode or by reducing the interval between meals.

Distraction: Desire to eat: Sensory-specific satiety: Dietary restraint: Attention: Disinhibition

The potential for food intake to increase when a meal is consumed under conditions of high cognitive load (Ward & Mann, 2000; Mann & Ward, 2004), or when distracted (Bellisle & Dalix, 2001; Wansink & Park, 2001; Boon *et al.* 2002; Bellisle *et al.* 2004), is well documented. These findings are important, because larger meal sizes represent an important predictor of obesity (Levitsky, 2005). While recent studies have explored the extent to which individuals differ in their sensitivity to the effects of distraction (Ward & Mann, 2000; Mitchell & Brunstrom, 2005), the reason why distraction influences eating behaviour has remained unclear.

Meals that are consumed with others tend to be both larger and longer (de Castro, 1990, 1994; de Castro & Brewer, 1992) than those eaten alone. Therefore, one possibility is that distraction serves to prolong the duration of an eating episode, thereby increasing the amount of food that is subsequently consumed. Consistent with this idea, obese participants are more likely to terminate their meals when a concurrent task, for example a television programme, ends (Tuomisto *et al.* 1998). An alternative proposition derives from the observation that (in the absence of food) people can 'forget' to eat when engrossed in a task. One possibility is that a similar phenomenon extends to occasions when an individual eats during distraction. In this context, distraction limits an individual's capacity to monitor signals associated with satiety. Consistent with this idea, it has been suggested that normal dietary control requires access to a degree of 'cognitive resource' (Boon *et al.* 2002). Since distraction-related overeating has been observed most frequently (although not exclusively) in restrained eaters (e.g. Ward & Mann, 2000, but see Boon *et al.* 2002), an added possibility is that the demands of cognitive restraint further undermine attempts to monitor these signals.

One way to explore these ideas is to use a crossover design, incorporating a 'distraction' and a 'no distraction condition'. However, when tested in this way the participants may suspect that they should behave or feel differently in the two conditions. This is problematic, because it makes it difficult to rule out the possibility that their responding is based on demand characteristics. To address this problem, we tested two different groups of participants in Experiment 1. In one group, participants were required to consume a fixed portion of a palatable snack, at regular intervals, over a 5 min period. The participants in a second group completed the same task while performing a highly engaging cognitive task. Our decision to use a relatively short eating episode was motivated by a concern to ensure that the participants attended continuously to the task. In both the no distraction and the distraction condition, measures of hunger, fullness and desire to eat were taken both before and after eating. In so doing, our aim was to determine the effect of distraction on several measures of satiety. We were also interested to explore whether the effects of distraction are moderated by everyday dietary behaviour (dietary restraint and disinhibited eating).

Abbreviations: DEBQ, Dutch Eating Behaviour Questionnaire; TFEQ, Three Factor Eating Questionnaire.
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Experiment 1

Method

Participants. Eighty-eight female undergraduate students were recruited using advertisements posted around the Loughborough University campus (mean age 19·52 (SD 1·69) years). All were paid £5 (Sterling) for their participation. The Loughborough University Ethics Committee gave approval for the research carried out in this experiment and also in Experiment 2. From the outset, participants were informed that they would be asked to provide a measure of their height and weight. However, they were also told that participation in this aspect of the experiment was optional. This decision was motivated by a concern to sample individuals from a wide distribution of eating behaviours, including those who might otherwise decline to take part because of concerns associated with their body weight or body image.

Subjective measures and questionnaires. At different times during the experiment, 100 mm visual-analogue scales were used to obtain ratings of hunger, fullness and desire to eat. Specifically, participants were asked, ‘How hungry/full do you feel right now?’ and ‘How strong is your desire to eat right now?’ Ends were anchored ‘Not at all hungry/full/strong’ and ‘Extremely hungry/full/strong’ on the left- and right-hand sides, respectively.

Dietary behaviour was assessed using the restraint section of the Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien *et al.* 1986) and the disinhibition scale of the Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985). The DEBQ-restraint scale was chosen because it identifies those individuals who successfully limit their dietary intake (Heatherton *et al.* 1988) and because it has been used previously in studies exploring the relationship between restraint and cognitive performance (e.g. Green & Rogers, 1995). The DEBQ-restraint scale contrasts the TFEQ-disinhibition scale, which identifies a failure to maintain dietary control and a tendency to overeat (Westenhoefer *et al.* 1994).

Distractor task. The distractor task was a commercially available computer game called ‘Pong’ (produced by Atari Inc.), which was presented on a 14-inch colour television. In Pong, the player is represented on the screen by a coloured cursor. The player can move the cursor using a joystick. The activity of the computer is represented by a similar cursor. Respectively, the player and computer assume right and left positions on the screen. During the game, the player and computer ‘bounce’ a virtual ball back and forth. One point is awarded to a player when their opponent fails to return the ball. The first player to score twenty-one points wins the game.

Food. In this experiment participants consumed five Jaffa Cakes (chocolate-covered sponge cake with orange-flavoured filling). This snack product is widely available in the UK (McVities, London, UK; 193 kJ (46 kcal) per 8 g cake).

Procedure. Participants were tested between 14.00 and 18.00 hours in individual cubicles in the Ingestive Behaviour Laboratory at Loughborough University. All were instructed to abstain from eating for at least 3 h prior to the onset of the experiment. Compliance with this request was verified using a questionnaire. On arrival, participants were randomly allocated to the distraction or the no-distraction condition. They were then briefed about the procedure. When completing ratings of hunger, fullness and desire to eat, they were told to ‘not think too hard. Just go with your instantaneous response’. After confirming that they understood these instructions the participants completed the initial ratings of hunger, fullness and desire to eat. Participants were then left alone for 5 min. During this period they were required to eat five Jaffa Cakes, at the rate of one every 60 s. A timer was used to signal the end of every 60 s interval. Those participants allocated to the no-distraction condition completed this procedure while sitting in silence. Those allocated to the distraction condition were instructed to complete this procedure while playing Pong for the full 5 min duration. At the end of the fifth 60 s interval (after all five Jaffa cakes had been consumed) participants completed a second set of ratings relating to hunger, fullness and desire to eat. They were then issued with the DEBQ-restraint and TFEQ-disinhibition scales. If the participant consented, a measure of height (cm) and weight (kg) was also taken. Five participants declined to be weighed; three in the distraction group and two in the no-distraction group. All participants were then paid, debriefed and thanked for their participation.

Data analysis. For each participant, we calculated a set of ‘change’ scores (pre-intake minus post-intake) for our measures of hunger, fullness and desire to eat. The change scores associated with each condition were then compared using independent *t* tests. In addition, we used regression analysis to establish whether an effect of distraction is modified by one of our measures of everyday dietary behaviour. Specifically, we were interested to determine whether an interaction exists, either between dietary restraint and distraction condition or between dietary disinhibition and distraction condition.

Results

Group characteristics. One participant in the no-distraction group failed to eat all five Jaffa Cakes. Consequently, her data were excluded from the analysis. Distracted and non-distracted participants were very similar (see Table 1). Across these groups, BMI (t[77] 1·19, $P=0·24$) and scores on the DEBQ-restraint (t[83] 0·90, $P=0·37$) and the TFEQ-disinhibition scale (t[83] 0·74, $P=0·46$) did not differ significantly.

Effects of distraction on the change in hunger, fullness and desire to eat. The distracted and non-distracted groups had

Table 1. Mean BMI, Dutch Eating Behaviour Questionnaire (DEBQ)-restraint and Three Factor Eating Questionnaire (TFEQ)-disinhibition scores, and mean initial hunger, fullness and desire to eat ratings (mm), for the distraction and no distraction groups in Experiment 1*

(Mean values and standard deviations)

	Distraction (*n* 44)		No distraction (*n* 43)	
Group	Mean	SD	Mean	SD
BMI (kg/m^2)	22·60	2·78	23·41	3·34
DEBQ-restraint	2·76	0·77	2·61	0·86
TFEQ-disinhibition	6·80	4·50	7·35	3·49
Initial hunger	58·14	21·27	61·93	23·87
Initial fullness	26·25	19·46	22·56	20·93
Initial desire to eat	52·57	27·17	59·00	24·37

* For details of procedures, see p. 762.

similar baseline hunger (t[83] 0·78, P=0·45), fullness (t[84] 0·85, P=0·40) and desire to eat (t[84] 1·16, P=0·25) ratings (Table 1). The change scores associated with these measures are shown in Fig. 1. Non-distracted participants reported a significantly greater increase in fullness (t[83] 2·50, P=0·014) and a significantly greater reduction in desire to eat (t[84] 2·09, P=0·04). They also experienced a greater reduction in hunger. However, this difference narrowly missed significance (t[83] 1·95, P=0·055).

Relationship between everyday dietary behaviour and the effects of distraction. We conducted a set of regression analyses to determine whether changes in hunger, fullness or desire to eat are predicted by an interaction between distraction condition and dietary restraint or dietary disinhibition. In every case, the associated interaction term failed to reach significance (P values in the range 0·232–0·412).

Discussion

The main aim of Experiment 1 was to assess the effect of distraction during a meal on changes in hunger, fullness and desire to eat. The data indicate that the presence of a distractor task attenuates the changes that otherwise occur in these measures. Further, this phenomenon appears to be universal, as little evidence was found to indicate variation associated with DEBQ-restraint or TFEQ-disinhibition scores (although see later for further comment on this issue). Previously, distraction has been associated with a reduction in hunger (Herman *et al.* 1999). Here, the converse was found – hunger is preserved. The reason for this discrepancy is unclear. However, it seems likely that the effects of distraction are dependent on the context in which it occurs. In relation to this idea, it is important to note that in the study by Herman *et al.* (1999) distraction was not contemporaneous with food intake. Rather, appetite was simply assessed before and after watching a video. Indeed, these authors acknowledge that when attention is directed to a concurrent task during a meal, then subjective hunger and eating behaviour are likely to interact in a complex way.

There are at least two reasons why the distraction task might influence the way that ratings change. Previously, it has been argued that the potency of direct controls (i.e. those that arise from contact with pre-absorptive receptors that are located from the tongue to the end of the small intestine) can be modulated by other indirect controls (e.g. cognitive) (Smith, 1996). If this is the case, then it follows that the effects of distraction could be general. That is, the distractor task might inhibit an individual's opportunity to attend to the visceral sensations associated with the development of satiety, and this stalls the general decline in hunger and desire to eat that normally occurs during a meal.

An alternative possibility is that the effects of distraction are more specific. Normally, sensory-specific satiety (Rolls, 1986) occurs when the same food is consumed repeatedly. However, this process might be arrested when food is experienced in conjunction with distraction. Consistent with this idea, distraction appears to delay the development of salivary habituation to a food cue (Epstein *et al.* 1997, 2005). This is important, because this kind of habituation is functionally quite similar to sensory-specific satiety. Both result from repeated exposure to the sensory properties of a food, irrespective of energy content (e.g. Rolls *et al.* 1988; Epstein *et al.* 1993), and the decrease in salivation that indicates habituation also tends to be accompanied by a reduction in ratings associated with the hedonic properties of the food (Wisniewski *et al.* 1992). In Experiment 1, we compared changes in desire to eat one food (Jaffa Cakes). Consequently, it remains unclear whether the distraction/no distraction condition differentially effects changes in the desirability of all foods or only the specific food that is consumed. Experiment 2 incorporated a more comprehensive set of comparisons involving other types of food, thereby facilitating an assessment of the potential 'specific' and 'general' effects of the distractor task.

A 'standard' sensory-specific satiety paradigm involves participants eating to satiety and then completing pleasantness ratings before and at regular intervals after a meal has terminated. Participants rate both the food that forms the meal and a set of uneaten foods, the particular food that is consumed is counterbalanced across participants, and sensory-specific satiety is assumed to occur when ratings for the eaten food decrease relative to ratings for the uneaten foods. Here, we decided to deviate from this basic design in two ways. First, in Experiment 2 the eaten food was not counterbalanced. Instead, as in Experiment 1, participants always consumed Jaffa Cakes. This

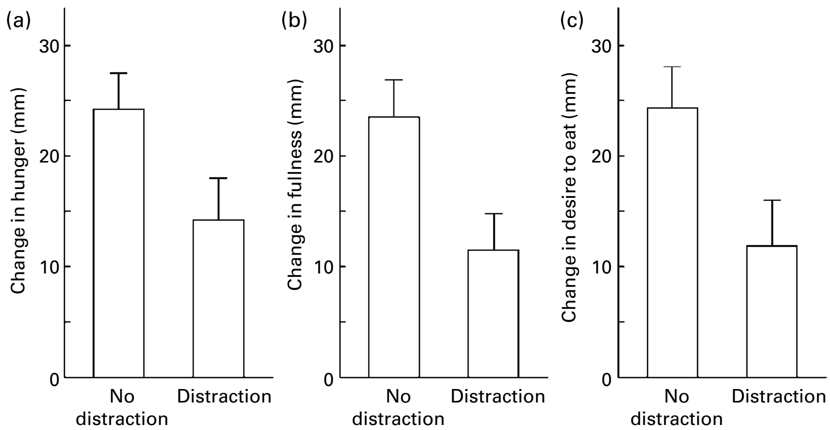

Fig. 1. Mean change in hunger (a), fullness (b) and desire to eat (c) for the distracted and the non-distracted participants in Experiment 1. For details of procedures, see p. 762. Values are means with their standard errors depicted by vertical bars.

approach enabled us to maintain a degree of consistency across experiments. However, it also limits the extent to which we can assume that the present findings generalise to all eaten and uneaten food pairings. To ensure that this distinction is transparent, we will reflect this constraint by referring to the present results in terms of 'food-specific' rather than 'sensory-specific' satiety. Second, rather than allowing *ad libitum* access to food, as in Experiment 1 (five Jaffa Cakes), we chose to give participants a single, fixed, portion size. This reasoning was motivated by the possibility that distraction simply delays the onset of sensory-specific satiety. This is important, because under *ad libitum* conditions we might expect to find little difference between distracted and non-distracted participants. This is because both groups will experience a similar degree of food-specific satiety – it will simply take distracted participants longer to arrive at this state. A related problem with *ad libitum* eating is that any comparison across groups will be confounded by differences in meal duration, making it difficult to disentangle the effects of distraction and meal duration. To address these problems we measured the development of food-specific satiety after participants achieved only partial satiety. Also, by controlling meal size we were able to compare the development of food-specific satiety at a common time-point in both groups.

A further motivation here was a more general concern to characterise the effects that distraction might have on hunger and pleasantness. Previous studies have focused solely on the effects of a distractor within or immediately after a period of distraction. Consequently, it remains unclear whether the effects of distraction persist for a period after an eating episode has terminated. To explore this issue, in Experiment 2, measures of general and food-specific satiety were assessed, both before, and at three time-points after consuming a fixed quantity of Jaffa Cakes.

Experiment 2

Overview

Participants were allocated randomly to a distraction or a no-distraction group. Three identical sets of 100 mm ratings were issued on four separate occasions – at baseline, and then immediately, 5 and 10 min after consuming five Jaffa Cakes. Each set included a rating of pleasantness, intensity and desire to eat. One set was used to assess the Jaffa Cakes. The others were used to assess two different 'uneaten' foods, against which the Jaffa Cakes were compared. Each time that the food-specific measures were issued the participants also provided a more general indication of their current appetite (hunger, fullness and desire to eat). In this way, two sets of measures were obtained, one that related to general aspects of appetite and one that assessed the momentary pleasantness of, and desire to eat, specific foods.

Method

Participants. Eighty-four female undergraduate students were recruited using advertisements posted around the Loughborough University campus (mean age 21·24 (SD 0·54) years). All were paid £5 (Sterling) for their participation. As in Experiment 1, we were concerned to sample individuals from a wide distribution of eating behaviours. Participants were informed that they would be asked to provide a measure of their height and weight, but that involvement in this aspect of the procedure was voluntary.

Subjective measures and questionnaires. Measures of general appetite (hunger, fullness and desire to eat) were obtained using the same 100 mm rating scales as in Experiment 1. For the food-specific measures the participants completed the following ratings; 'How pleasant is the taste of the food in your mouth?' (end anchors 'very unpleasant' and 'very pleasant'), 'How intense is the taste of the food in your mouth?' (end anchors 'very weak' and 'extremely strong') and 'How strong is your desire to eat more of this food right now?' (end anchors 'not at all strong' and 'extremely strong'). As in Experiment 1, participants also completed the DEBQ-restraint and the TFEQ-disinhibition scales.

Foods. Again, as in Experiment 1, participants ate five Jaffa Cakes. The uneaten foods were bacon-flavoured corn snacks ('Frazzles'; Walkers Snack Foods Ltd, Leicester, UK, 1975 kJ (470 kcal) per 100 g) and mandarin fruit segments (Tesco Stores Ltd, Cheshunt, UK, 315 kJ (74 kcal) per 100 g). A 200 ml glass of water was also provided to allow participants to clean their palate between samples. This was removed during the main eating episode.

Procedure. Participants were tested between 14.00 and 18.00 hours in individual cubicles in the Ingestive Behaviour Laboratory at Loughborough University. All were instructed to abstain from eating for at least 3 h prior to the onset of the experiment. Compliance with this request was verified using a questionnaire. On arrival, the participants rated their hunger, fullness and desire to eat (general measures). They were then presented with a tray containing the three food samples. Participants were instructed to taste each sample and to rate their individual pleasantness, intensity and desire to eat after consuming each one in turn (specific measures). The bacon-flavoured snack (one corn chip = approximately 3 g, 59 kJ (14 kcal)) was always tasted first, followed by the mandarin fruit segment (one segment = approximately 8 g, 25 kJ (6 kcal)) and the Jaffa Cake sample (a quarter portion of a single cake = approximately 2 g, 50 kJ (12 kcal)). Participants were instructed to take a sip of water after consuming each sample.

After completing these ratings, the procedure for the 5 min eating episode was explained. This was identical to Experiment 1. Half of the participants ate while sitting in silence. The other half ate while playing Pong continuously. At the end of the eating episode, all of the participants completed a second set of general appetite ratings followed by a second assessment of the three food samples. When they had finished this task they were left alone to sit in silence. This procedure was then repeated 5 and 10 min after the end of the eating episode.

Finally, the participants completed the DEBQ-restraint scale and the TFEQ-disinhibition scale. At this point a measure of height (cm) and weight (kg) was taken from those participants who consented to this aspect of the procedure (n 79). The participants were then paid, debriefed and thanked for their assistance with the experiment.

Data analysis. In this experiment, sets of ratings were issued before, and then immediately, 5 and 10 min after the eating episode. For each of the general and food-specific ratings, change scores were calculated based on the difference between baseline ratings (t_{base}) and those taken after the eating episode ($t_{0\,min}$, $t_{5\,min}$ and $t_{10\,min}$). In this way, for each type of rating and each participant, three scores were derived that reflected how the ratings changed after eating relative to baseline.

To analyse changes in the general measures of appetite (hunger, fullness and desire to eat), each set of change scores was submitted to a mixed-model ANOVA. Respectively, 'distraction' (no distraction/distraction) and 'time' (change at $t_{0\,min}$, $t_{5\,min}$ and $t_{10\,min}$) were included as a between- and a within-subject factor.

To assess evidence for food-specific satiety we used a similar mixed-model ANOVA. Sensory-specific satiety is normally evidenced by a reduction in the pleasantness of an eaten food relative to uneaten foods. Accordingly, in our analysis we explored the extent to which pleasantness change scores are predicted by an interaction between 'food type' (eaten and uneaten), 'time' and 'distraction'. To determine whether these variables predict our other food-specific measures, the same three-way ANOVA was also applied to the change scores relating to intensity and desire to eat.

At each time-point, linear regression analyses were also conducted to assess whether changes in 'general' and 'food-specific' appetite are predicted by an interaction between distraction group and everyday dietary behaviour. For the general measures of appetite (hunger, fullness and desire to eat), the change scores associated with each time-point were entered into a separate regression model. For the food-specific measures (pleasantness, intensity and desire to eat), a single measure of food-specific satiety was derived at each time-point by subtracting the change score associated with the uneaten food from the change score associated with the eaten food. These scores were also entered into separate regression models.

Results

Group characteristics. Table 2 shows the mean BMI, TFEQ-disinhibition score and DEBQ-restraint score associated with the distracted and the non-distracted groups, separately. It also includes their mean baseline ratings of hunger, fullness and desire to eat. A comparison across groups revealed no significant differences in any of these measures (all $P>0{\cdot}05$). For each of the three foods, Table 3 shows the baseline ratings of pleasantness, intensity and desire to eat. Again, across groups, no significant differences were found (all $P>0{\cdot}05$).

Table 2. Mean BMI, Dutch Eating Behaviour Questionnaire (DEBQ)-restraint and Three Factor Eating Questionnaire (TFEQ)-disinhibition scores, and mean initial hunger, fullness and desire to eat ratings (mm), for the distraction and the no distraction groups in Experiment 2*

(Mean values and standard deviations)

	Distraction (*n* 42)		No distraction (*n* 42)	
Group	Mean	SD	Mean	SD
BMI (kg/m^2)	22·86	2·74	22·77	2·67
DEBQ-restraint	2·66	0·89	2·86	0·76
TFEQ-disinhibition	7·64	3·10	7·90	3·40
Initial hunger	64·00	22·58	60·55	18·52
Initial fullness	20·98	17·61	24·95	13·67
Initial desire to eat	64·24	24·79	62·79	17·55

*For details of procedures, see p. 764.

Effect of distraction on changes in hunger, fullness and desire to eat. Relative to baseline, Fig. 2 shows the change in hunger, fullness and desire to eat at the three time-points after the 5 min eating episode.

Change in hunger and fullness: changes in hunger differed significantly across time (F[2,164] 12·79, $P<0{\cdot}001$). However, the effect of time on change in fullness narrowly missed significance (F[2,164] 2·89, $P=0{\cdot}059$). Changes in hunger and fullness were generally larger in the no-distraction group. However, these differences were modest and they failed to reach significance (hunger, F[1,82] 0·32, $P=0{\cdot}58$; fullness, F[1,82] 0·30, $P=0{\cdot}59$). Likewise, the interactions between distraction and time were not significant (hunger, F[2,164] 1·46, $P=0{\cdot}24$; fullness, F[2,164] 0·079, $P=0{\cdot}92$).

Change in desire to eat: the main effect of distraction condition was significant (F[1,82] 4·32, $P=0{\cdot}041$), indicating that the non-distracted participants experienced a greater overall reduction in desire to eat than did the distracted participants. 'Time' was also identified as a significant factor, suggesting that in both groups, the reduction in desire to eat changed during the course of the experiment (F[2,164] 3·49, $P=0{\cdot}033$). However, the interaction between time and distraction was not significant (F[2,164] 1·25, $P=0{\cdot}29$), indicating that these effects operate independently (Fig. 2(c)).

Effect of distraction on food-specific satiety. *Change in pleasantness*: Fig. 3 shows the change in pleasantness associated with both the uneaten foods (Fig. 3(a, b)) and the eaten food (Fig. 3(c)). Across foods, the effect of distraction condition did not reach significance (F[1,82] 0·32, $P=0{\cdot}25$). Likewise, the main effect of time narrowly missed significance (F[2,164] 2·95, $P=0{\cdot}055$). However, a comparison across foods revealed a main effect of food type (F[1,82] 39·45, $P<0{\cdot}001$).

The greatest reduction in pleasantness occurred in the eaten food. This pattern of results is consistent with evidence for food-specific satiety. However, the critical interaction between food type and distraction condition failed to reach significance (F[1,82] 2·85, $P=0{\cdot}095$).

Table 3. Mean ratings of pleasantness, intensity and desire to eat (mm) the three food samples at baseline for the distraction and the no distraction groups in Experiment 2*

(Mean values and standard deviations)

	Distraction (*n* 42)		No distraction (*n* 42)	
Group	Mean	SD	Mean	SD
Bacon-flavoured corn snack				
Pleasantness	73·50	18·09	72·19	22·66
Intensity	69·83	21·27	71·36	21·30
Desire to eat	66·64	23·85	63·31	25·47
Mandarin fruit segment				
Pleasantness	73·39	21·35	75·31	19·78
Intensity	57·52	17·47	57·83	18·69
Desire to eat	55·12	28·81	60·43	26·22
Jaffa Cake				
Pleasantness	69·33	22·04	74·90	23·24
Intensity	62·26	18·44	68·17	17·35
Desire to eat	55·69	26·96	59·93	27·59

* For details of procedures, see p. 764.

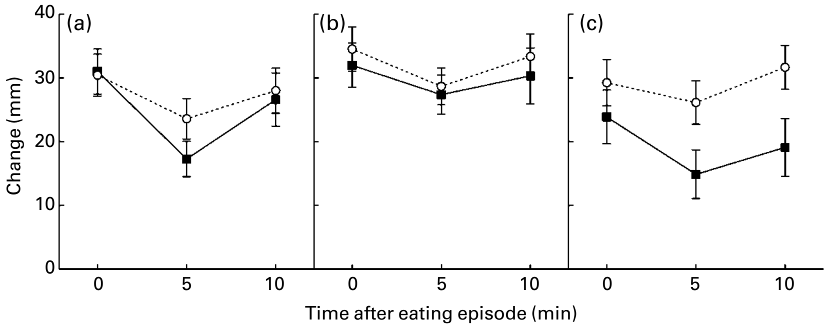

Fig. 2. Mean change in hunger (a), fullness (b) and desire to eat (c), for the distracted (■) and the non-distracted participants (○), 0, 5 and 10 min after the eating episode in Experiment 2. For details of procedures, see p. 764. Values are means with their standard errors depicted by vertical bars.

Change in intensity: Fig. 4 shows the changes in intensity that occurred in the eaten food (Fig. 4(c)) and the two uneaten foods (Fig. 4(a, b)). Taken together, the change in the intensity of the foods differed significantly across time (F[2,162] 3·11, P=0·047). However, the data indicate little evidence for a clear trend. In both groups the intensity of the two uneaten foods did not differ greatly from baseline. With regard to the eaten food, a different pattern of results was observed, and this difference was confirmed by a significant interaction between food type and time (F[2,164] 6·86, P=0·002). Generally, the distracted group experienced a modest increase in the intensity of the eaten food over time, whereas the no-distraction group tended to produce lower intensity ratings throughout. However, in relation to this difference, it is noteworthy that the interaction between condition and food type failed to reach significance (F[1,82] 1·65, P=0·20), as did the main effect of condition (F[1,82] 1·44, P=0·23) and the main effect of food type (F[1,82] 1·54, P=0·22).

Change in desire to eat: the changes in desire to eat were not dissimilar to the changes in pleasantness. Fig. 5 shows that participants experienced a slightly greater decline in their desire to eat the eaten food (Fig. 5(c)) compared with the uneaten foods (Fig. 5(a, b)). Consistent with this observation, food type emerged as a significant predictor in an analysis of change scores (F[1,82] 51·46, P<0·001).

In terms of the effects of distraction, Fig. 5(a, b) shows that both distracted and non-distracted participants experienced the same modest changes in their desire to eat the non-eaten foods. By contrast, a relatively marked reduction was observed with regard to the eaten food, but only in non-distracted participants. This food-specific effect was confirmed by a significant interaction between food type and distraction (F[1,82] 5·77, P=0·019). Further t tests confirmed that the decline in the desire to eat Jaffa Cakes was significantly greater in the no-distraction group at $t_{5\,min}$ (t[82] 2·67, P=0·018) and at $t_{10\,min}$ (t[82] 2·83, P=0·012) (at $t_{0\,min}$ the same difference failed to reach significance (t[82] 1·50, P=0·274)).

Finally, ANOVA also revealed a significant interaction between time and food type (F[2,164] 3·09, P=0·048) and between time and distraction condition (F[2,164] 7·40, P=0·001). The main effect of distraction condition (F[1,82] 3·27, P=0·074) and the main effect of time (F[2,164] 1·33, P=0·27) both failed to reach significance.

Correlation between changes in pleasantness and desire to eat. In order to ascertain the extent to which changes in pleasantness and desire to eat are related, a correlation coefficient was calculated at each time-point, and in each group separately. All of these coefficients were significant (all P<0·001, r values in the range 0·357–0·616).

Relationship with Dutch Eating Behaviour Questionnaire and Three Factor Eating Questionnaire scores. As in Experiment 1, a set of regression analyses was used to determine whether the effects of distraction are more or less evident in those individuals who score highly on measures of dietary restraint and disinhibited eating. Accordingly, for each general measure (changes in hunger, fullness and desire to eat) and each food-specific measure (changes in pleasantness, intensity and desire to eat), an appropriate interaction

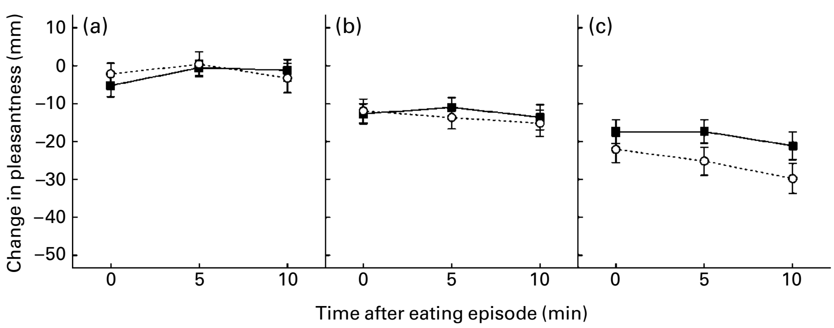

Fig. 3. Mean change in pleasantness for the bacon-flavoured corn snack (a), mandarin fruit segment (b) and Jaffa Cake (c), for the distracted (■) and the non-distracted participants (○), 0, 5 and 10 min after the eating episode in Experiment 2. For details of procedures, see p. 764. Values are means with their standard errors depicted by vertical bars.

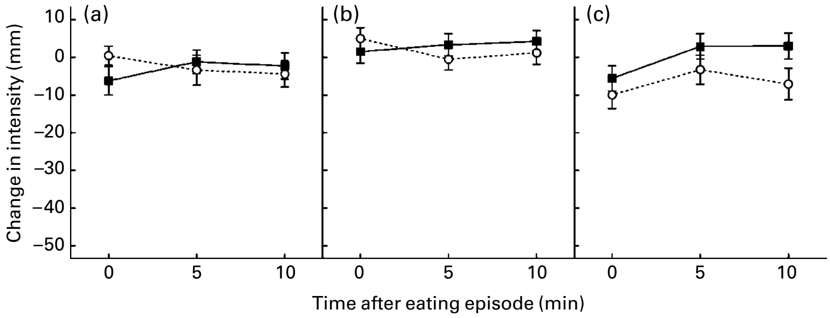

Fig. 4. Mean change in intensity for the bacon-flavoured corn snack (a), mandarin fruit segment (b) and Jaffa Cake (c), for the distracted (■) and the non-distracted participants (○), 0, 5 and 10 min after the eating episode in Experiment 2. For details of procedures, see p. 764. Values are means with their standard errors depicted by vertical bars.

term was calculated to establish the extent to which the effect of distraction is moderated by these measures of dietary behaviour. Since there were six different measures (three general and three food-specific), three time-points ($t_{0\,min}$, $t_{5\,min}$ and $t_{10\,min}$) and two assessments of behaviour (restraint and disinhibition), a total of thirty-six separate regression analyses ($6 \times 3 \times 2 = 36$) were conducted.

For the measures of general appetite, all interaction terms failed to reach significance (*P* values in the range 0·055–0·970). For the food-specific measures, all interactions failed to reach significance (*P* values in the range 0·061–0·970), with the exception of one – 10 min after the eating episode the difference in change in desire to eat between the eaten and uneaten foods was predicted by an interaction between the TFEQ-disinhibition scores and distraction group (*t* 2·35, *b* − 4·123, SE 1·756, *P*= 0·021). Based on the number of separate tests performed, this isolated case is easily attributable to chance.

Discussion

Consistent with Experiment 1, participants experienced a greater reduction in their general desire to eat when they were required to eat without distraction. This effect was evident 10 min after the distractor task had terminated and it increased over this period (at 0 min the difference between distracted and non-distracted groups failed to reach significance). A trend was also observed indicating that distraction limits the changes in hunger and fullness that are otherwise found in non-distracted participants. However, unlike in Experiment 1, the effects of distraction failed to reach significance. The reason why this aspect of Experiment 1 was not replicated is unclear. Procedurally, it may be relevant that participants completed fewer types of ratings in Experiment 1. In Experiment 1, changes were expected in both general ratings of hunger and fullness and in specific ratings related to the Jaffa Cakes. By contrast, in Experiment 2 we anticipated that some of our ratings would remain relatively constant (ratings associated with the uneaten foods). One possibility is that measures of hunger and fullness do not assess abstract motivational constructs. Rather, they either reflect directly, or at least are affected by, our momentary disposition to consume a particular food or foods (Booth, 1981, 1994; Kramer *et al.* 1992). If this is the case then we might anticipate relatively modest changes in rated hunger and fullness in Experiment 2. This is because, unlike in Experiment 1, participants were encouraged to think about their appetite for several types of foods, the majority of which (the uneaten foods) remained relatively unaffected by the eating episode.

A further aim was to determine whether food-specific satiety develops to the same extent in distracted and non-distracted participants. Owing to various methodological constraints (outlined earlier) it was not possible to incorporate the same measures and design features that are typical in studies of sensory-specific satiety. Nevertheless, with regard to ratings of desire to eat, both groups experienced a greater decline in their desire to eat the eaten relative to the uneaten foods. Importantly, a comparison across groups revealed that this decline was greater in individuals who were not distracted during eating, particularly when assessed 5 and 10 min after the distraction task had terminated.

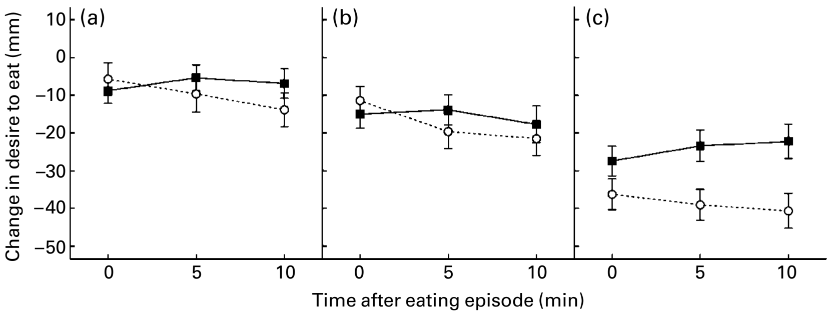

Fig. 5. Mean change in desire to eat the bacon-flavoured corn snack (a), mandarin fruit segment (b) and Jaffa Cake (c), for the distracted (■) and the non-distracted participants (○), 0, 5 and 10 min after the eating episode in Experiment 2. For details of procedures, see p. 764. Values are means with their standard errors depicted by vertical bars.

Typically, sensory-specific satiety is evidenced by changes in ratings of pleasantness rather than by changes in ratings of desire to eat. However, in the present study changes in desire to eat were consistently correlated with changes in pleasantness, indicating a close correspondence between both measures. Other aspects of the data are also consistent with the notion that food-specific satiety occurred. For example, sensory-specific satiety appears to generalise from an eaten food to an uneaten food that has a similar flavour (Johnson & Vickers, 1993). In the present study a degree of generalisation was also observed. Specifically, one of the uneaten foods, the mandarin fruit segments, was similar to the Jaffa Cakes, because both had an 'orangey flavour'. Generally, the pleasantness of this uneaten food was found to decline more than the pleasantness associated with the other uneaten food (bacon-flavoured corn snack).

Alternatively, differential effects of distraction on ratings of pleasantness and desire to eat might indicate that distraction influences 'liking' and 'wanting' in different ways. Despite the fact that separate brain substrates have been identified for each of these processes (Berridge, 1996), their independent operation is difficult to establish using the kind of subjective measures that were employed here (Hetherington & Rolls, 1996). Nevertheless, this general proposition represents a potentially interesting area for future research.

General discussion

Several aspects of the findings warrant further scrutiny. First, one possibility is that the effects of distraction extend beyond 10 min. Indeed, after a prolonged period of distraction, they might even extend for a few hours. This possibility merits serious consideration, because this kind of process has the potential to reduce the time interval between meals, thereby increasing average daily energy intake. Consistent with this idea, observations of everyday dietary behaviour reveal that meal frequency is often higher when meals are consumed during distraction (Stroebele & de Castro, 2004). Furthermore, sensory-specific satiety effects have been observed up to 2 h after eating cessation (Weenen *et al.* 2005), indicating that effects of distraction might also operate over a similar period of time.

Second, in the present study the game 'Pong' was selected because it is highly engrossing. As such, it has the capacity to distract players away from sensations and cognitions associated with the food that they are consuming. However, an alternative proposition is that Pong also changes levels of stress. This is relevant, because cortisol secretion is a major component of the stress response (Koo-Loeb *et al.* 2000) and it has been implicated as a potential mediator of increased energy intake in males (Epel *et al.* 2001). However, in relation to this account of the present data, it is worth noting that more stressful events such as a cold-stress test (placing a limb in ice-cold water) do not appear to have a significant effect on cortisol levels over short periods of time, such as the 5 min required to eat the Jaffa Cakes (Gluck *et al.* 2004). Instead, they tend to peak some time after (20–40 min) the onset of the stressor (Brandenberger *et al.* 1980; Holl *et al.* 1984). More generally, isolating the relative effect of stress and cognitive distraction has proved very difficult in the past, and stress induction does not appear to be a reliable predictor of overeating (Shapiro & Anderson, 2005). Furthermore, in response to other recent findings, it has been suggested that stress-induced eating should, in any case, be attributed to the cognitive, distracting effects of the stressor rather than to its negative effect on arousal or its effect on perception of self-image (Lowe & Kral, 2006). Notwithstanding these points, in the context of the present design, we are unable to disambiguate the cognitive distracting and the potential stress-inducing effect of Pong. Instead, further research is needed in order to establish its role as a distractor with absolute certainty.

Third, it has been suggested that the effects of distraction are particularly evident in individuals who restrict their dietary intake (Ward & Mann, 2000). By contrast, the data in the present study indicate that the effects of distraction are general, affecting all participants alike. In relation to this difference, it might be relevant that the distractor task was extremely engrossing. In this context, both restrained and unrestrained eaters may be distracted passively from monitoring their intake. On the other hand, less engrossing tasks might offer greater opportunity for varying levels of engagement (for evidence of this phenomenon see Mitchell & Brunstrom, 2005). A further extension of the present research might involve an assessment of individual differences under conditions where participants are exposed to different kinds of distractor task. It might also be relevant that we obtained a measure of dietary restraint shortly after the participants had consumed a prescribed portion of food. Although the DEBQ-restraint subscale has excellent test–retest reliability (Banasiak *et al.* 2001), it is possible that responses are affected when the scale is issued under these conditions. More generally, decisions about the assessment of dietary restraint could prove to be critical. In relation to this idea it should be noted that Ward & Mann (2000) chose to code their restraint scores as high or low based on a pre-specific cut-off. They also used a different measure of restraint, and this was issued several weeks prior to the beginning of their study.

Finally, the finding that distraction arrests a process akin to sensory-specific satiety is highly relevant to researchers with an interest in meal size. This is because sensory-specific satiety is regarded as an important determinant of meal termination (Hetherington, 1996). However, it is important to emphasise that we have focused solely on the effects of distraction in the context of a fixed meal, and this limits the extent to which parallels can be drawn between the present findings and those from *ad libitum* eating paradigms. In future, studies should seek to consider the effects of distraction in a context that has greater ecological validity. Here, our aim has been to explore basic principles, and it remains to be established whether these generalise to a normal meal. In particular, our decision to limit the eating episode to a fixed 5 min period and to provide food in a tightly controlled context was motivated by a concern to be able to provide unambiguous evidence for an effect of cognitive distraction. A challenge for future studies will be to explore how these methods can be applied to study eating behaviour under normal conditions.

In summary, to the authors' knowledge, the present research represents the first of its kind to explore the effects of distraction both within a meal and over a short period after meal termination. The results indicate that distraction has a potent effect on the changes in desire to eat that normally occur during a meal. Moreover, these effects appear to operate in a food-specific manner and they persist after the distraction period has ended. One possibility is that distraction has a similar effect in everyday activities such as watching television and so on. Given the continued interest in the relationship between these behaviours and obesity in children and adolescence (e.g. Hancox & Poulton, 2006), this phenomenon merits further consideration.

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