Playing a computer game during lunch affects fullness, memory for lunch, and later snack intake\textsuperscript{1,2}

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**ABSTRACT**

**Background:** The presence of distracting stimuli during eating increases the meal size and could thereby contribute to overeating and obesity. However, the effects of within-meal distraction on later food intake are less clear.

**Objective:** We sought to test the hypothesis that distraction inhibits memory encoding for a meal, which, in turn, increases later food intake.

**Design:** The current study assessed the effects of playing solitaire (a computerized card-sorting game) during a fixed lunch, which was eaten at a fixed rate, on memory for lunch and food intake in a taste test 30 min later. A between-subjects design was used with 44 participants. Participants in the no-distraction group ate the same lunch in the absence of any distracting stimuli.

**Results:** Distracted individuals were less full after lunch, and they ate significantly more biscuits in the taste test than did nondistracted participants (mean intake: 52.1 g compared with 27.1 g; \( P = 0.017 \)). Furthermore, serial-order memory for the presentation of the 9 lunch items was less accurate in participants who had been distracted during lunch.

**Conclusions:** These findings provide further evidence that distraction during one meal has the capacity to influence subsequent eating. They may also help to explain the well-documented association between sedentary screen-time activities and overweight. *Am J Clin Nutr* 2011;93:308–13.

**INTRODUCTION**

The time spent engaged in sedentary behaviors is likely to be a critical factor in the development of excess adiposity (1, 2). Sedentary behaviors, such as watching television, might decrease daily energy expenditure (3). However, it is their association with food intake that may be more important in promoting obesity (4, 5). Recent studies indicated that eating while engaged in activities such as watching television and listening to music increased the amount of food consumed (6–10). This effect appears to be due to the distracting properties of such activities (9), perhaps limiting the attention that might otherwise be directed toward visceral sensations generated during a meal and leading to overeating (7, 11, 12).

In addition to observations within a meal, the effects of distraction appear to be evident even after the meal has ended. In one study, participants ate either with or without concurrent distraction. Ten minutes after meal termination, distracted participants reported greater hunger and less fullness (13). Furthermore, memory for food in one meal appears to reduce intake at a subsequent meal (14, 15). One possibility is that these findings reflect a general role for memory of recent eating in the regulation of appetite and food intake (16). If this is the case, then eating while distracted may degrade the quality of this memory trace and, thereby, promote an increased intake at a subsequent meal. In a recent article, Higgs and Woodward (17) reported data that were consistent with this idea. Participants consumed a fixed lunch while watching television. On a separate occasion, they consumed the same lunch in the absence of television. After 2.5 h, participants who consumed lunch while watching television reported a relatively lower vividness for the lunch and consumed a larger portion of a snack food. For the first time, these findings provided evidence that distraction during one meal had the capacity to influence the meal size later in the day (17).

The current study extended the work of Higgs and Woodward (17) in several ways. First, because distraction is known to increase eating rate (6, 18), we standardized the rate of eating across conditions by serving small portions of foods at 90-s intervals. Second, we quantified the effect of distraction on subsequent memory for a meal by asking participants to recall the nature and presentation order of the lunch foods. Third, differential effects of television viewing on food memory have been shown in individuals who regularly or rarely eat while engaged in this activity (19). Therefore, we explored the effect of an alternative source of distraction (playing a computer game) on food intake and memory. Finally, we used a between-subjects design to minimize effects of practice, sensitization, and carryover, which tend to be associated with within-subjects designs (20). We predicted that 1) participants who eat lunch while playing a computer game would consume a relatively greater amount of snack food in the postmeal period, and 2) distracted participants would have a less accurate memory of the item and serial presentation order of food items consumed during lunch.

**SUBJECTS AND METHODS**

**Participants**

Forty-four participants (22 men and 22 women) were recruited via online advertisements and by word of mouth. Vegetarians,\textsuperscript{1}

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vegans, and those with other specific dietary requirements were excluded. Nonhabitual breakfast consumers were not excluded. As a cover story, participants were informed that the experiment was designed to investigate the effect of food on memory for a word list. The protocol was approved by the local Faculty of Science Human Research Ethics Committee.

Overview

An overview of the study procedure is shown in Table 1. All participants were tested at lunchtime (1230 or 1400) and were allocated to one of 2 conditions. Participants were served 9 savory lunch items. In the distraction condition, participants played a computerized card-sorting game (solitaire) while eating lunch. In the no-distraction condition, lunch was eaten in the absence of this distracter. Ratings of mood, hunger, and fullness were obtained immediately after the meal, and participants were given a word list to memorize within 1 min. Thirty minutes later, all participants took part in a biscuit taste test (17, 21) in which biscuits were rated on a number of sensory characteristics (ie, pleasant, salty, sweet, and sour). Participants recalled the word list and were also asked to recall the lunch foods eaten and the order in which they were presented. Participants completed the restraint scale of the Dutch Eating Behavior Questionnaire (DEBQ) (22) and were asked to indicate their beliefs about the true purpose of the experiment. Finally, their height and weight were measured.

Lunch items and biscuit test foods

The weight and energy content of each lunch item is provided in Table 2 (total: 235.39 g and 471.5 kcal, respectively). All lunch items were manufactured by Sainsbury's Ltd (London, United Kingdom) with the exception of the potato chip snack (Hula Hoops; KP Snacks Ltd, Ashby-de-la-Zouch, United Kingdom). Specific items were prepared as follows: the cheese sandwich consisted of a one-half slice of white bread, 10 g cheddar cheese, and 5 g butter. The ham sandwich consisted of a one-half slice of bread, 10 g ham, and 5 g butter.

The taste test involved the ad libitum intake of 3 flavors of biscuit. These were chocolate chip cookies (Burton’s Foods, St Albans, MD; 511 kcal/100 g), milk chocolate digestive biscuits (a sweet, plain biscuit covered in chocolate, Sainsbury’s Ltd; 493 kcal/100 g), and sweet oat-based biscuits [Hobnobs, 467 kcal/100 g; McVities, United Biscuits (UK) Ltd, Hayes, United Kingdom].

Food-memory measures

Two measures were used to test memory for the lunch meal. Participants were first asked to write down all lunch items that they remembered consuming (free recall), which were scored by the number of items correctly reported (maximum: 9 items). For the second measure, participants recalled the order in which the food items had been presented (serial-order recall). With the use of a complete list of all lunch foods that had been consumed, participants provided a number (1–9) to denote the order of presentation of each item. Serial-order recall was scored as the number of items recalled in the correct serial position of presentation in the meal.

Word-list recall

In line with the cover story that the experiment was designed to investigate the effect of food on memory for words, participants were presented with a word list that comprised the names of 6 countries and 6 capital cities. For the measure of word-list memory, participants were required to write down the words that had been presented to them (maximum number: 12). The word list had the added benefit of acting as a control for general differences in memory between conditions; we expected no significant differences between conditions for this measure.

Anthropometric and self-report measures

During the taste test, participants rated the pleasantness, saltiness, sweetness, and sourness of each biscuit in turn. Ratings were anchored by not at all on the left and extremely on the right. Pleasantness ratings were included to establish whether a difference in intakes might otherwise be attributed to a differential liking for the biscuits across conditions. Mood was assessed after lunch with the Positive and Negative Affect Scale (PANAS) (23) to identify any between-condition differences in mood that resulted from the presence or absence of solitaire-playing during lunch. The PANAS comprised 2 10-item scales that relate to positive and negative affect. Items are adjectives (eg, inspired and nervous) that are each rated by the participant for their accuracy in describing the participant’s current mood. Ratings were made on a scale that ranged from 1 (very slightly or not at all) to 5 (extremely). Appetite was assessed after lunch by using visual-analog scales that contained the adjectives hungry and full and were accompanied by 100-mm unmarked lines anchored by not at all on the left and extremely on the right. Appetite was not assessed before the meal because this measure could have

### Table 1

Overview of the study procedure

<table>
<thead>
<tr>
<th>Time and activity</th>
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<tbody>
<tr>
<td>0 min</td>
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<tr>
<td>Arrive at laboratory and instructions for lunch</td>
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<tr>
<td>10 min</td>
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<td>Lunch, with either distracting card-sorting game present or no distraction</td>
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<td>25 min</td>
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<td>Rate fullness and hunger</td>
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<td>Memorize word list</td>
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<td>Complete PANAS mood ratings</td>
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<tr>
<td>30 min</td>
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<tr>
<td>Break</td>
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<tr>
<td>60 min</td>
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<tr>
<td>Biscuit taste test with sensory ratings</td>
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<tr>
<td>Word-list recall task and lunch meal memory (free recall and serial-order recall)</td>
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<td>80 min</td>
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<tr>
<td>Complete DEBQ–restraint scale</td>
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<td>Report food consumed before arrival at laboratory</td>
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<tr>
<td>Demand awareness measure</td>
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<tr>
<td>95 min</td>
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<td>Measurement of weight and height</td>
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<tr>
<td>100 min</td>
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<tr>
<td>End of test session</td>
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</table>

1 PANAS, Positive and Negative Affect Scale; DEBQ, Dutch Eating Behavior Questionnaire.
increased the self-monitoring of intake and thus affected the attention manipulation in distracted participants.

At the end of the experiment, we assessed demand awareness. Specifically, participants were instructed to “Please write down what you believe this experiment was about.” To assess compliance with our instructions, all participants wrote down the time of their last meal and the food and drink items that they consumed between waking and arriving at the laboratory. The restraint scale of the DEBQ was used to measure restrained eating (ie, the tendency to consciously restrict food intake). Height (in m) was measured with a stadiometer, and weight (in kg) was recorded with outdoor clothes and shoes removed.

Procedure

Participants were tested alone at 1230 or 1400. For each participant, sessions were allocated to promote a correspondence with a normal lunchtime. Participants were requested to abstain from eating lunch on the day of their testing session.

Participants in the distraction condition ate lunch while playing solitaire; this game could be played with one hand by using a computer mouse. Participants were instructed to win as many games as possible. Those in the no-distraction condition were simply instructed to attend to the sensory characteristics of the foods. All other instructions were identical for both conditions. During lunch, individual portions of food were issued at 90-s intervals via a serving hatch, beginning with the cheese twist followed by the ham sandwich and ending with the cheese sandwich. The biscuits were presented separately in 3 bowls that contained 200 g of each biscuit type. Biscuits were broken to prevent subjects from using a counting strategy to promote a normative consumption. Water (250 mL) was provided for the taste test, and participants were instructed to clear any remaining biscuits from their mouth before rating the next biscuit type in line with the taste-test cover story. Participants were advised that they had 10 min to make sensory ratings and were welcome to eat as many or as few of the biscuits as they wished. After 10 min, the biscuits were removed and weighed to determine the amount consumed while participants recalled the word list and completed the free recall and serial-order recall tasks for lunch foods. Participants reported any food consumed before arrival at the laboratory on the day of testing, returned their responses to the demand-awareness measure, and completed the DEBQ. Finally, measures of height and weight were obtained.

Statistical analyses

All statistical analyses were conducted with SPSS software (version 16.0; SPSS Inc, Chicago, IL). Descriptive statistics (means ± SDs) were calculated for all variables by condition (lunch consumed in the presence or absence of distraction). Independent t tests were used to test for baseline differences in age, height, weight, body mass index (BMI; in kg/m²) and restrained eating. A multivariate analysis of variance was conducted on the main outcome variables (ie, biscuit intake, serial-order recall, and free recall of lunch items, hunger, and fullness) with sex and condition as between-subject factors. The effect of condition on biscuit consumption (in g) was assessed by using a 2-factor analysis of variance (ANOVA) with the condition (distraction compared with no distraction) and sex (men compared with women) as between-subject factors. To test the effect of condition on memory for lunch, separate 2-factor ANOVAs (condition and sex) were carried out with serial-order recall and free recall as the dependent variables, respectively. Effects on postlunch appetite (hunger and fullness), mood ratings (PANAS), rated liking (pleasantness) of the biscuits, and memory for the word list were also each assessed by 2-factor ANOVA (condition and sex).

RESULTS

Participant characteristics

Twenty-two participants were tested in the distraction condition, and 22 subjects were tested in the no-distraction condition (between-subject design). In each case, equal numbers of men and women were tested. Across conditions, we showed no significant differences between participants in the distraction and no-distraction conditions for age (28.1 ± 17.2 and 26.3 ± 15.0 y, respectively) height (173.7 ± 7.4 and 174.2 ± 9.4 cm, respectively), weight (69.6 ± 10.3 and 71.7 ± 12.3 kg, respectively), BMI (23.1 ± 3.0 and 23.6 ± 3.07, respectively), and restrained eating (2.45 ± 0.94 and 2.31 ± 0.86 arbitrary units, respectively) (all P > 0.53).

Multivariate analysis

The multivariate analysis of variance performed on the main dependent variables (ie, biscuit intake, serial-order recall, and free recall of lunch items, hunger, and fullness), with sex and condition as between-subjects factors, revealed significant main effects of condition [Pillai’s trace = 0.281, F (5,36) = 2.812, P < 0.05] and sex (Pillai’s trace = 0.428, F (5,36) = 5.387, P < 0.01)
but no significant condition-by-sex interaction. On this basis, effects of sex and condition were explored for each dependent measure by using separate 2-factor ANOVAs.

Biscuit intake

Thirty minutes after lunch, participants in the distraction condition consumed significantly more biscuits than those in the no-distraction condition \( F(1,40) = 6.17, P = 0.017 \) (Table 3). There was no significant difference between men and women for biscuit intake and no significant condition-by-sex interaction.

Food memory

The serial-order recall of the specific lunch foods was significantly less accurate for participants in the distraction condition than for nondistracted participants \( F(1,40) = 5.37, P = 0.026 \) (Table 3). There was no significant difference between men and women for serial-order recall, and no significant condition-by-sex interaction.

For the free recall of the lunch foods, there was no significant difference in performance across conditions. The mean number of items recalled in the distraction and no-distraction conditions was 8.0 ± 1.0 and 8.1 ± 1.0, respectively (Table 3). Regardless of the condition, women recalled significantly more lunch foods (8.5 ± 0.8 items) than did men (7.6 ± 1.1 items) \( F(1,40) = 8.9, P = 0.005 \). There was no significant condition-by-sex interaction for free recall of the lunch foods \( (P > 0.05) \).

Self-reported hunger and fullness

Immediately after lunch, participants in the distraction condition reported feeling significantly less full than those in the no-distraction condition \( F(1,40) = 4.3, P = 0.044 \). Effects of condition on hunger failed to reach significance (Table 3).

After lunch, men reported significantly greater hunger than women (men: 28.5 ± 21.4 mm; women: 11.1 ± 9.3 mm) but no significant condition-by-sex interaction. On this basis, effects of sex and condition were explored for each dependent measure by using separate 2-factor ANOVAs.

Mood, liking for biscuits, and word-list recall

There were no significant main effects of condition or sex and no sex-by-condition interactions for mood (PANAS), liking for biscuits, or number of words recalled from the word list (all \( P > 0.05 \) (Table 3).

Manipulation check

When prompted, no participant correctly guessed the purpose of the experiment. Consistent with the cover story, 19 participants mentioned memory in their response. Only one participant mentioned distraction. However, this response referred to “hunger and fullness with distraction, emotional relationships with food, no idea with the biscuits.”

DISCUSSION

Previous research has indicated that distraction during a meal can increase subsequent food intake (17). In our study, we tested the hypothesis that this occurs because distraction impairs the encoding of memories relating to the meal (17). To explore this idea, we sought to determine whether playing a computer game during lunch resulted in poorer memory for the lunch and a relatively greater intake of a snack food in a subsequent taste test. Our findings confirmed this to be the case. Thirty minutes after the lunch, distracted participants consumed ≈100% more biscuit than did nondistracted participants. Distracted participants also reported lower fullness immediately after lunch. In addition, the serial-order memory for the presentation of lunch foods was significantly poorer in distracted participants, which suggested that they had a degraded memory for the lunch. These differences were unlikely to have been mediated by differences in mood, weight or BMI, sex, age, liking for the biscuits, or dietary restraint because participants were well-matched across conditions. In addition, our participants failed to guess the true purpose of the study. Therefore, these results were unlikely to reflect specific demand characteristics.

Instead, we suggest that our findings provide further evidence that distraction during a meal has the capacity to influence meal size later in the day. To our knowledge, this is only the second study to consider effects of within-meal distraction on subsequent food intake (17). Higgs and Woodward (17) reported effects on intake 2.5 h after consuming a lunch while distracted. By contrast, we observed effects after 30 min, and in an earlier study, we reported effects of distraction on rated appetite after only 10 min (13). Together, these findings indicate that the effects of distraction are not limited to a single period in the postmeal interval. We also found that the effects of distraction were evident in both men and women. Previously, this effect has only been explored in women (17). Further, our results show that the effects of distraction are not limited to watching television and appear to generalize to other screen-time behaviors. This observation may have particular relevance to the development of population-level strategies that aim to prevent or reduce overweight and obesity.

In relation to the specifics of our study design, we also note that our participants consumed discrete portions of food at 90-s...
intervals. Distraction appears to increase eating rate (6, 18), and thus, our innovation controlled for this potential confound. In this study, we also incorporated 2 quantifiable measures of memory: serial-order recall for lunch food presentation and lunch-item recall. Consistent with previous evidence on the basis of self-report vividness ratings (17), participants in the distraction condition had poorer memory for the food eaten during lunch, albeit only in our measure of serial recall. We suspect that our failure to find differences in free recall might be attributed to a ceiling effect. In both conditions, most participants remembered 8 or 9 out of the 9 foods during lunch. A ceiling effect for the free recall task but not for the serial order recall task is perhaps unsurprising because participants generally achieve higher scores on free-recall tasks (24).

In addition, we note that our participants reported relatively less fullness after eating a fixed portion during distraction. This result replicates previous findings, (13) and it complements evidence from related studies showing that distraction can promote a marked increase in ad libitum intake despite little difference in postmeal ratings of hunger and fullness (6, 8). We consider that there are 2 potential explanations for the postmeal difference in fullness we report between our distracted and nondistracted participants. The first is that distraction weakened or limited the ability of individuals to attend to visceral sensations generated by eating, which resulted in lower fullness. The second possible explanation is that distraction did not interfere with the generation or experience of visceral sensations themselves, but interfered with the ability to correctly attribute visceral sensations to recent eating. Consistent with this second explanation, amnesic patients failed to show normal decreases in hunger after eating even large amounts of food (25, 26). Indeed, one patient refused a fourth consecutive meal on the grounds that his “stomach was a little tight,” although it appeared that he was unable to attribute this sensation to recent eating (25). Similar findings have been reported in dementia patients who show signs of hyperphagia (27). A role for memory in the correct attribution of satiety signals to recent eating could fit well with our data. To further explore this possibility, future studies might include more extensive measures of memory for a meal such as an assessment of memory for portion sizes of the foods consumed. Researchers might also consider potential ceiling effects in some measures of memory for a meal. In addition, researchers might consider the relative merits of including prelunch ratings of hunger and fullness. We chose not to include these measures because we wanted to limit attention that might be drawn to eating and appetite during the lunch (something that might mitigate against the effects of distraction). Participants were randomly allocated to each group. Therefore, we saw little reason to expect differences in baseline hunger and fullness across conditions. Nevertheless, these ratings could help to justify a claim of this kind.

Our findings are highly relevant to today’s society where a multitasking mentality is especially prevalent (19). One US study reported that up to a one-quarter of children’s total energy intake was consumed while watching television (28). Furthermore, in a study of overweight women, almost one-half of all weekly meals were reportedly consumed in a room with a television set switched on (29). Both cross-sectional and intervention research indicate that the positive association between screen-time and obesity is most likely mediated by increased food intake as opposed to reduced physical activity (4, 30, 31). Although exposure to food advertisements (9, 32, 33) and reduced habituation to food cues (9) have been suggested as possible mechanisms, we propose that screen-time behaviors also have the capacity to increase food intake after their termination, most likely via an impairment of memory for recent eating. In the current study, we provided further evidence that was consistent with this idea. However, in the future, it will be important to show a causal relation between memory for a recent meal and subsequent intake and to consider the effect of a wider range of distracting sedentary behaviors on immediate and later eating.

The authors’ responsibilities were as follows—REO-C, CEN, PJR, and JMB: were responsible for the design of the study; REO-C and CEN: collected data; REO-C, CAH, CEN, and JMB: conducted data analysis; and all authors: contributed to the preparation of the manuscript. None of the authors declared a conflict of interest.

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