Television watching increases motivated responding for food and energy intake in children[1–3]

Jennifer L Temple, April M Giacomelli, Kristine M Kent, James N Roemmich, and Leonard H Epstein

ABSTRACT

Background: Sedentary activities, such as watching television, may disrupt habituation to food cues, thereby increasing motivation to eat and energy intake.

Objective: These experiments were designed to examine the effect of television watching on habituation of ingestive behavior in children.

Design: In experiment 1, all children worked for access to cheeseburgers in trials 1–7 (habituating stimulus). In trials 8–10, children in the control group continued to work for cheeseburgers without any dishabituating stimuli, whereas children in the other groups received either a novel food (French fries) or television as dishabituating stimuli. Responding for food and amount of food eaten were measured. In experiment 2, all children had access to 1000 kcal of a preferred snack food. One group watched a continuous television show, and the control groups either watched no television or watched a repeated segment of a television show, which controls for the television stimulus but requires reduced allocation of attention.

Results: In experiment 1, both the novel food and the television watching groups reinstated responding for food ($P = 0.009$) and increased the amount of energy earned ($P = 0.018$) above the level of the control subjects. In experiment 2, the continuous television group spent more time eating ($P < 0.0001$) and consumed more energy than the no television and the repeated segment groups ($P = 0.007$).

Conclusion: These experiments show that television watching can dishabituate eating or disrupt the development of habituation, which may provide a mechanism for increased energy intake associated with watching television.   *Am J Clin Nutr* 2007;85:355–61.

KEY WORDS   Habituation, obesity, ingestive behavior, sedentary activity, attention

INTRODUCTION

The prevalence of pediatric obesity in the United States is increasing (1, 2). Child weight is influenced by multiple factors, including accessibility of high-energy-density food (3) and increased time engaged in sedentary activities such as watching television and playing video games (4–7). In addition, attentional allocation to stimuli such as television (8, 9), radio (8, 10), and social interactions (10–14) leads to increases in meal energy intake. Current estimates suggest that 20–25% of daily energy is consumed in front of the television (5). Children (5) and adults (3) increase their intake of high-energy-density foods while watching television. In addition, increasing sedentary behaviors, including television watching, increased energy consumption; most of the increased consumption occurred while the subjects were watching television (15).

One way in which watching television may contribute to excess eating is by disrupting habituation to food cues. Habituation to food cues is a well-established phenomenon that is ubiquitous across species (16–24) and is regulated by integrated signals from sensory systems, neuronal systems, and the digestive system (25). Habituation can be modified by providing food-related (26, 27) and nonfood-related (28) stimuli that require allocation of attention from the habituating stimulus.

If the same food cue is repeatedly presented and the person reduces behavioral (27) or physiologic (24, 26) responding for that food, then presentation of a novel food will reinstate responding for food. Likewise, presentation of a nonfood cue can reinstate responding for food after habituation to that food (23, 28, 29), but no research has compared the relative degrees of reinstatement of responding to food and nonfood cues.

Environmental distracters that are presented concurrently with presentation of food cues can shift attention away from processing food cues and slow the rate of habituation to food cues (23, 30, 31). For example, playing a video game or engaging in a difficult arithmetic task while playing a video game slowed subjects' salivary habituation more than did a no-stimulation condition (22, 23). Performing a computer task that required attentional resources disrupted habituation in adults and children more than did a similar task that required fewer attentional resources or no computer task (23, 28). Finally, auditory distracters reduced

TABLE 1
Characteristics of participants in experiment 1[1]

	Group			
Descriptive variables	Control (n = 9)	Novel food (n = 11)	Television (n = 10)	P
Age (y)	11.1 ± 1.2	10.9 ± 1.1	11.1 ± 1.5	0.9
Socioeconomic status[2]	43.8 ± 13.9	42.0 ± 15.3	49.1 ± 11.5	0.5
BMI (kg/m²)	18.7 ± 2.5	18.2 ± 1.9	22.6 ± 2.6	0.9
BMI percentile	60.6 ± 34.9	57.3 ± 29.6	57.6 ± 28.0	1.0
Hunger[3]				
Before intervention (score)	4.0 ± 1.3	3.8 ± 1.3	3.9 ± 1.1	0.9
After intervention (score)	1.9 ± 0.9	1.3 ± 0.5	1.5 ± 0.7	0.2
Self-reported calories (kcal)	701 ± 395	799 ± 398	761 ± 374	0.9

[1] All values are $\bar{x}$ ± SD. No significant differences in any of these characteristics were found between groups.

[2] From the Hollingshead demographics questionnaire; possible values ranged from 13 to 66.

[3] From a 5-point Likert-type scale, with "Not very hungry" at 1 and "Extremely hungry" at 5.

habituation in children when compared with a no auditory stimulation control condition (28). Thus, shifting attention away from eating is another way in which watching television can influence habituation to food cues.

The present experiments were designed to test the hypothesis that television watching increases energy intake by reinstating eating after habituation has occurred. Experiment 1 compared the degree of dishabituation after presentation of a television stimulus with presentation of a novel, palatable food. Experiment 2 assessed whether presentation of television concurrently with access to a favorite snack food increased the time spent eating and the energy intake more than did 2 control conditions, a no television control and a condition that presented repeated segments of the same television show, thus controlling for the audiovisual stimulation but requires less attentional allocation.

SUBJECTS AND METHODS

Participants

On arrival to the laboratory, participants and parents read and signed assent and informed consent forms. All procedures for these studies were conducted in accordance with ethics guidelines set forth by the National Institutes of Health and with the approval of the University at Buffalo Health Sciences Institutional Review Board.

Experiment 1

Participants were 30 nonoverweight [body mass index (BMI; in kg/m²): <95th percentile] 9–12-y-old children (14 M, 16 F) who were recruited from a magazine advertisement and direct mailings. The average participant was 11.0 ± 1.1 y old, had a BMI of 18.4 ± 2.3, and was at the 58.4 ± 29.8 percentile for BMI (**Table 1**). Exclusionary criteria were as follows: current psychopathology or developmental disability, medications or conditions that could influence appetite or olfactory sensory responsiveness (eg, methylphenidate, upper respiratory illness, and diabetes), and dietary restrictions that would interfere with participation in the study. Participants were also required to report at least a moderate liking (3 on a 5-point Likert-type scale) of the study foods. The study sample included 77% non-Hispanic white, 7% Hispanic white, 13% African American, and 3% Asian children.

Experiment 2

Participants were 26 nonoverweight (<95th BMI percentile) 9–12-y-old children (12 M, 14 F). The average participant was 11.2 ± 1.2 y old, had a BMI of 18.2 ± 2.3, and was at the 55.2 ± 24.5 percentile for BMI (**Table 2**). Recruitment and eligibility criteria were the same as in experiment 1. The study sample included 88% non-Hispanic white, 8% Hispanic white, and 4% American Indian children.

TABLE 2
Characteristics of participants in experiment 2[1]

	Group			
Descriptive variables	Control (n = 9)	Repeated segment (n = 8)	Continuous television (n = 9)	P
Age (y)	11.4 ± 1.1	11.2 ± 1.5	11.0 ± 1.3	0.8
Socioeconomic status[2]	48.1 ± 9.3	50.3 ± 12.1	46.8 ± 14.5	0.8
BMI (kg/m²)	18.3 ± 2.7	17.5 ± 1.5	18.7 ± 2.5	0.5
BMI percentile	52.9 ± 29.4	48.8 ± 23.9	63.1 ± 26.7	0.5
Hunger before intervention (score)[3]	3.8 ± 0.7	4.0 ± 0.5	4.2 ± 1.1	0.5
Self-reported calories (kcal)	610 ± 274	724 ± 215	828 ± 637	0.6

[1] All values are $\bar{x}$ ± SD. No significant differences in any of these characteristics were found between groups. The control group had 5 boys (56%); the repeated segment group had 4 boys (50%); the continuous television group had 5 boys (56%).

[2] From the Hollingshead demographics questionnaire; possible values ranged from 13 to 66.

[3] From a 5-point Likert-type scale, with "Not very hungry" at 1 and "Extremely hungry" at 5.

Procedures

Parents of participants were screened by telephone to determine whether children met eligibility criteria, with the exception of liking of study foods, which was assessed during the laboratory session. Eligible participants were scheduled for 1 or 2 visits to the laboratory between the hours of 1400 and 1700. Parents were instructed that children were not to consume the study foods 24 h before the appointments and were not to eat or drink (except water) 3 h before the appointments. Participants were compensated US\$20 for participation in experiment 1 and US\$30 for experiment 2.

After providing informed consent, parents completed the demographics questionnaire (32), and participants completed same-day dietary recall and hunger scales. After the parent was escorted from the room, children completed additional scales that assessed food preferences and the Dutch Eating Behavior Questionnaire adapted for children to assess dietary restraint (33). In experiment 1, children were randomly assigned to 1 of 3 conditions: control (no dishabituating stimulus), novel food (French fries in trials 8–10), and television (television stimulus in trials 8–10). Each participant's height and weight were measured at the end of the session. For experiment 2, children were randomly assigned to 1 of 3 groups: no television group, repeated segment group, and continuous television group. The children completed an energy intake task on one day and a salivary habituation task (data not presented) on the other day. These tasks were completed on different days, and the order of the tasks was counterbalanced.

Motivated responding task (experiment 1)

A computer-generated, variable interval task was used to assess motivated responding for food (27). The task required children to press a mouse button, which caused either one of the squares to flash a color: the bottom square flashed red (0 points earned), or the top square flashed green (1 point earned). In this task, participants responded on a variable interval schedule of 120 s, which means that the first response made after an average interval of 120 s was reinforced, and they received a 100-kcal portion of food. Participants were told before starting that they could play the computer task to earn points for food to eat and that, when they no longer wanted to earn points to eat, they could play with alternative activities (ie, magazines, crosswords, and word finds). Participants could move freely between the computer task and the alternate activities.

The task consisted of ten 2-min time blocks; for the first 7 time blocks, participants in all groups worked toward one-half of a junior cheeseburger ($\approx$100 kcal). Previous research has shown that >95% of lean 9–12-y-olds will show cessation of responding for food by the end of seven 2-min trials (27). For the last 3 trials, participants in the control group continued to work for portions of cheeseburgers, participants in the novel food group worked for French fries (37 g, 100 kcal), and those in the television group continued to work for cheeseburgers while watching a 6-min clip of a television show. At the beginning of the session, participants were not told how many trials they would have, nor were participants in the novel food group told that they would receive French fries. To control for any potential disruption of habituation caused by an acute auditory stimulus, all groups were told before trial 8 what foods they would be working for, even if that food was the same food for which they had

previously been working. In addition, the computer screen displayed a picture of the food for which the child was working. During all trials, participants received the portion of food immediately after each point was earned, and they could continue to play the computer task to earn points while eating. During the session, participants were provided water ad libitum and could communicate with the experimenter over an intercom system. The dependent measure was the amount of time allocated to responding for food, which is consistent with research that used interval schedules of reinforcement (34).

Energy intake task (experiment 2)

Participants were seated in a comfortable armchair behind a desk and were asked to rank 4 snack foods (Smartfood White Cheddar Popcorn, Cool Ranch Doritos, Lay's Wavy Potato Chips, and Cheetos; all: Frito-Lay, Dallas, TX). Their favorite was used in the experiment. Participants in the no television group were not shown clips of television shows. Participants in the repeated segment and the continuous television groups watched 2.5-min clips of 3 family-friendly shows (*The Muppet Show*, *Punky Brewster*, and *Diff'rent Strokes*). These television shows were chosen because they are age-appropriate but relatively unfamiliar to children in the generation being tested. Participants ranked the shows, and their favorite of the 3 was used for the experiment.

Participants in all groups were given a 1000-kcal portion of their favorite snack food and provided water ad libitum. They were instructed to eat as much or as little of the snack food as they wanted and to let the experimenter know when they were finished. Hunger ratings were provided both before and after the session. Participants were able to communicate with the experimenter through an intercom system in the experimental rooms. During the consumption of the snack food, participants in the continuous television and the repeated segment groups both watched their favorite television show. The continuous television group was shown an episode of a television show that ran continuously from the beginning. The repeated segment group was shown a 1.5-min segment of a television show, which was repeated on a loop. Previous studies have shown that an external stimulus present repeatedly will not disrupt habituation, in comparison to a continuously changing external stimulus that requires allocation of attention (35). The repeated segment group provides a control for the presence of audiovisual stimulation that the continuous television group received, which made the primary difference between the repeated segment and the continuous television groups the amount of attention allocated to television watching. Participants in the no television group received no television or any other form of stimulation or entertainment. The session ended when either the participant said he or she no longer wanted to eat the snack food or after 23 min (the amount of time for a continuous half-hour episode of a television show, without commercials), whichever came first. This design controlled for the influence of the presence of the television alone by comparing a television stimulus that did not require attentional allocation after the first viewing (repeated segment) with a stimulus that required attentional allocation (continuous television).

Laboratory environment

The laboratory was specially constructed for eating and olfactory experiments. The laboratory is equipped with an air delivery

system that circulates new air through each room ≈10 times/h. The laboratory rooms are also equipped with high-efficiency particulate air purifiers, each containing a CPZ (Carbon, Permanganate, Zeolite) filter to remove odors from the air.

Measures

Motivated responding for food

Motivated responding for food was measured as the amount of time the participant spent engaged in the habituation task (described earlier) to earn points toward portions of food.

Energy intake

A Denver Instruments scale (accurate to 0.01 g) was used to calculate energy intake for both experiments by weighing the experimental food before and after presentation to the participant. The difference in the weights was the number of grams of food consumed. The energy consumed was calculated by multiplying the grams consumed by the energy density (in kcal/g) for each type of food. Energy densities used were those provided by the manufacturers on food labels (for snack foods) or in nutrition materials published by Wendy's (for cheeseburgers, hamburgers, and French fries).

Food hedonics and hunger

Liking of study foods and hunger were assessed in both experiments with the use of 5-point Likert-type scales anchored by "Do not like" or "Not very hungry" at 1 and "Like very much" and "Extremely hungry" at 5. A 40-item food questionnaire that included the study foods was also administered to ensure reliability of reported liking of study foods. For experiment 2, participants were also asked to rank the study foods, with a ranking of 1 indicating a participant's favorite.

Same-day food recall

Total energy consumption before the appointment was examined and calculated by using NUTRITIONIST V nutrient analysis software [version 2.2 (36)]. This measure was used to check adherence to the study protocol by ensuring that the participant had not consumed food or drink (except water) in the 3 h preceding the appointment and that he or she had not consumed the study foods that day.

Demographics

The Hollingshead demographics questionnaire was used to assess class, socioeconomic status, race, and ethnicity (32).

Anthropometrics

Height (in cm) and weight (in lb) were measured with the use of a digital stadiometer (Digi-Kit, North Bend, WA) and a digital weight scale (Tanita, Arlington Heights, IL), respectively, and were used to calculate BMI. Children were excluded if their BMI was >95th BMI percentile (37).

Statistical analysis

One-factor analysis of variance (ANOVA) and chi-square tests were used to compare descriptive characteristics, hunger, and same-day preexperimental energy consumption between groups. Between-group differences in motivated responding (the amount of time the subject engaged in responding for food) and

energy consumption were analyzed with the use of a repeated-measures ANOVA with group as the between-subject factors and trials as the within-subject factor. Separate analyses were conducted on the habituation phase of the experiment (trials 1–7) and the recovery phase of the experiment (trials 8–10). Linear contrasts were performed to test whether differences existed between the experimental groups (television group compared with novel food group) and then to compare the pattern of responding between the control group and the experimental groups (control group compared with television group and novel food group) during both phases of the experiment. To correct for the multiple comparisons (2), the significance levels were Bonferroni adjusted and considered significant only if $P < 0.025$.

In experiment 2, group differences in the amount of energy and grams of food consumed, the amount of time spent eating, and the hunger ratings before and after testing were analyzed by using a one-factor ANOVA. Linear contrasts were performed first to compare the 2 control groups (no television and repeated segment). After no differences were observed between these groups, a second linear contrast was performed to compare the control groups (no television and repeated segment) with the continuous television group. As in experiment 1, to correct for these multiple comparisons, the results were considered significant only if $P < 0.025$.

RESULTS

Experiment 1

No significant differences were observed in any characteristic between groups (Table 1). A significant habituation of responding during the first 7 trials ($P < 0.0001$; **Figure 1**A) was observed, and no significant differences were seen between the experimental groups ($P = 0.47$) or between the control group and the experimental groups ($P = 0.27$). In addition, a similar decrease was observed in the amount of energy earned across the first 7 trials ($P < 0.0001$; Figure 1B), and no significant differences were seen between the experimental groups ($P = 0.68$) or between the control group and the experimental groups ($P = 0.40$).

Linear contrasts showed that, for the pattern of responding in trials 8–10, the control group was significantly different from the television and the novel food groups both for time spent responding ($P = 0.009$) and for amount of energy earned ($P = 0.018$), but no significant differences were observed between the experimental groups for responding for food ($P = 0.99$) or for energy earned ($P = 0.683$).

Experiment 2

No significant differences were observed among the groups in any of the descriptive characteristics examined (Table 2). No significant differences were observed in the television shows or the snack foods selected as favorites ($P > 0.05$). A significant main effect of groups was observed for grams ($P = 0.024$) and energy ($P = 0.02$) consumed and for time spent eating ($P < 0.0001$; **Figure 2**A, B, and C). Post hoc comparisons showed no significant differences in grams ($P = 0.96$) or energy ($P = 0.81$) consumed or in time spent eating ($P = 0.08$) between the no television group or the repeated segment control group. The continuous television group consumed significantly more grams ($P = 0.007$) and more energy ($P = 0.007$) and spent significantly
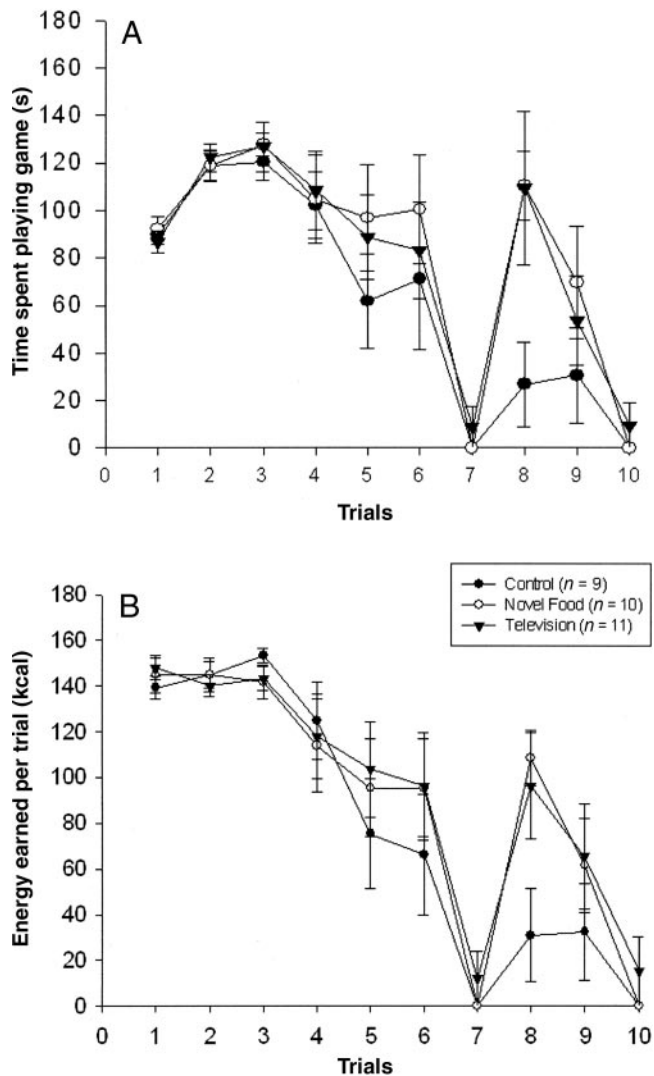
FIGURE 1. Mean (±SEM) amount of time (in s) spent responding for access to food (A) and mean (±SEM) amount of energy (in kcal) earned (B) by children who responded for cheeseburgers in all trials and had no television (control; $n = 9$), children who responded for cheeseburgers in trials 1–7 and then could respond for French fries in trials 8–10 (novel food; $n = 10$), or children who responded for cheeseburgers in all trials but had the television turned on for trials 8–10 (television; $n = 11$). Repeated-measures ANOVA showed that all groups habituated to the food stimulus for both responding ($P < 0.0001$) and energy earned ($P < 0.0001$) during the first 7 trials ($P < 0.0001$), but the novel food and the television groups reinstated responding ($P = 0.0009$) and calories earned ($P = 0.018$) in trials 8–10 relative to the control group. No significant differences were observed between the television and the novel food groups for any of the analyses.

more time eating ($P < 0.0001$) than did the no television and the repeated segment groups combined. Despite differences in food intake among the groups, no significant differences were observed in hunger ratings after the session ended ($P = 0.76$).

DISCUSSION

These experiments tested the hypothesis that television watching disrupts habituation, resulting in increased motivated responding for food and increased energy intake. Experiment 1 showed that television watching was as effective as a novel food
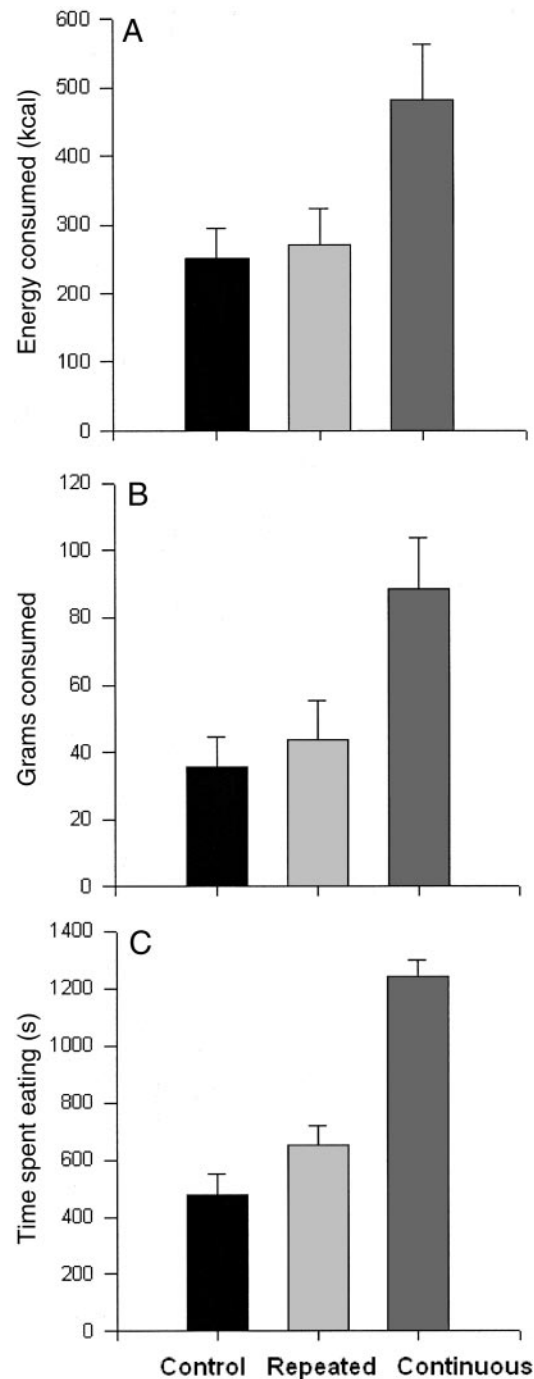

FIGURE 2. Mean (±SEM) energy (kcal; A) and number of grams (B) consumed and time spent eating (C) during the session by children who had no access to television (no television; $n = 9$), children who repeatedly watched a 1.5-min segment of a television show (repeated segment; $n = 8$), or children who watched a continuous television program (continuous television; $n = 9$). ANOVA showed that participants in the continuous television group consumed significantly more energy ($P = 0.0007$) and more grams of food ($P = 0.0003$) and spent significantly more time engaged in eating ($P < 0.0001$) than did those in the no television and the repeated segment groups. No significant differences were observed between the no television and the repeated segment groups.

in reinstating responding after habituation had occurred and that the children were no longer motivated to respond for food. This finding suggests that television, as was shown previously with

other attention tasks (28), disrupts habituation to food cues. In experiment 2, television watching increased the time spent eating, the amount of food eaten, and energy intake, but only when it required attentional allocation (the continuous television group but not the repeated segment group), which is consistent with the informational processing model of habituation (38, 39). When taken together, these data show that television is a highly salient stimulus that leads to the disruption of habituation to food cues. This is consistent with previous research showing that listening to an audiobook and engaging in a computer search task both inhibited habituation to an extent proportional to the amount of attention required for the task (28). Playing a video game or engaging in a laboratory stress task also disrupted habituation, and more stressful tasks were associated with greater disruption (22).

Previous studies showed that exposure to distracting stimuli can increase energy intake. For example, Stroebele and de Castro (9, 10) found that listening to music increased meal duration and watching television increased meal frequency, and that both resulted in increased intake of total energy. Similar findings were reported in research that compared television watching with listening to an audiobook, whereby both sets of stimuli increased meal size and meal energy intake relative to the control condition (8). Social interactions were also shown to increase meal duration and meal energy intake (8, 9, 11–14). These findings may be related to shifts in attentional allocation away from eating, in addition to more complex cognitive processes, such as social facilitation of eating, modeling of eating, and impression management (13).

In addition to effects of attentional allocation on energy intake, characteristics of the food being eaten can influence eating behavior. Habituation theory provides a model for understanding the influence of novel food stimuli on ingestive behavior (27). An alternative theoretical approach to explain the effect of introduction of a novel food on recovery of eating after satiety is sensory-specific satiety (19, 40). This theory states that the hedonic value of a food will decrease after the food is eaten to satiety, whereas the hedonic value of an uneaten food remains the same (19, 40). Although both theoretical perspectives can account for the role of a novel food in reinstatement of eating, as was seen after presentation of French fries in experiment 1, sensory-specific satiety cannot account for nonfood-related factors that also increase energy intake. Habituation theory provides a more general theoretical approach, in which any stimulus that alters attention may disrupt habituation and influence eating, whether the stimulus involves food cues or audiovisual cues, such as television. Theoretically, the similarity between novel foods and novel external stimuli may relate to the similar allocation of attention for both types of stimuli. It would be interesting to determine whether there is an additive or synergistic effect when both novel foods and novel external stimuli are presented simultaneously, or whether differential effects of food or external stimuli may be observed if the characteristics of the stimuli were made variable.

Television watching may influence eating through other mechanisms. For example, eating during television watching may by triggered by cues presented in food-related advertisements. Research has shown that most commercials shown during children's television viewing are for food products (41) and that most foods advertised are of high energy density and poor nutritional quality (19, 41, 42). Laboratory studies have shown that exposure to food-related advertisements, but not other types of advertisements, increased eating behavior in children, regardless of their weight status (43). Children as young as 2 y preferred products that they observed in television commercials over those they had not observed (43). Television may also influence eating through associative learning. Repeated episodes of eating while watching television may result in television's becoming a conditioned stimulus for eating (44, 45). Similarly, if eating in front of the television is habitual, over time, the television could also stimulate precephalic feeding cues and lead to subsequent eating. Data from adults indicate, as we have shown here, that eating while watching television increases energy intake (8, 9), and this increase may be due in part to television watching's becoming a conditioned cue for eating. To our knowledge, no human research has specifically tested this hypothesis.

The experimental results show that there is a relation between television watching and eating behavior. Television watching disrupts habituation, which leads to an increase in energy intake. In addition, because the types of food that children choose to eat while watching television tend to be of high energy density, television watching has the potential to profoundly affect total energy intake, even if this increase occurs in short, transient bouts. One of the limitations of this study is that we examined only acute energy intake. It would be interesting to learn whether habitual pairing of television watching and eating leads to chronic increases in energy intake. In addition, this study was conducted in nonoverweight children. Future studies will focus on the differences between lean and overweight children in response to environmental distracters.

Increased access to highly reinforcing sedentary activities, such as watching television and playing computer and video games (46), is a likely contributor to the ongoing obesity epidemic (47). Short-term intervention studies show that reductions in television watching are associated with reliable decreases in energy and dietary fat intake. In addition, several recent lines of research link television watching and obesity. There is general agreement that a positive relation exists between the number of hours that children spend watching television and their BMI (4, 44, 45, 48). When child television watching is reduced, reductions in BMI are also observed (49). Studies of food choice have shown that children who eat in front of the television consume significantly fewer servings of fruit, vegetables, and milk and significantly more servings of high-energy-density snack foods than do children who rarely eat while watching television (49–51). These data, combined with those from other studies (4, 42, 44, 45, 47–51), support recommendations to reduce television watching and restrict eating while watching television as part of a healthy lifestyle.

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