

Eating attentively: a systematic review and meta-analysis of the effect of food intake memory and awareness on eating^{1–4}

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ABSTRACT

Background: Cognitive processes such as attention and memory may influence food intake, but the degree to which they do is unclear.

Objective: The objective was to examine whether such cognitive processes influence the amount of food eaten either immediately or in subsequent meals.

Design: We systematically reviewed studies that examined experimentally the effect that manipulating memory, distraction, awareness, or attention has on food intake. We combined studies by using inverse variance meta-analysis, calculating the standardized mean difference (SMD) in food intake between experimental and control groups and assessing heterogeneity with the I^2 statistic.

Results: Twenty-four studies were reviewed. Evidence indicated that eating when distracted produced a moderate increase in immediate intake (SMD: 0.39; 95% CI: 0.25, 0.53) but increased later intake to a greater extent (SMD: 0.76; 95% CI: 0.45, 1.07). The effect of distraction on immediate intake appeared to be independent of dietary restraint. Enhancing memory of food consumed reduced later intake (SMD: 0.40; 95% CI: 0.12, 0.68), but this effect may depend on the degree of the participants' tendencies toward disinhibited eating. Removing visual information about the amount of food eaten during a meal increased immediate intake (SMD: 0.48; 95% CI: 0.27, 0.68). Enhancing awareness of food being eaten may not affect immediate intake (SMD: 0.09; 95% CI: -0.42, 0.35).

Conclusions: Evidence indicates that attentive eating is likely to influence food intake, and incorporation of attentive-eating principles into interventions provides a novel approach to aid weight loss and maintenance without the need for conscious calorie counting. *Am J Clin Nutr* 2013;97:728–42.

INTRODUCTION

Several effective behavioral programs are available to aid weight loss (1, 2). However, average weight loss typically slows some months into a program probably because adherence to dietary restriction gradually wanes, and weight regain after successful loss is the norm (3, 4). This may be in part because many weight-loss programs rely on the maintenance of effortful monitoring of food intake and vigilance of goal processes (4, 5).

It may be possible to develop simple strategies to assist people trying to lose or maintain weight loss that do not rely on conscious vigilance of calorie intake. Evidence has accumulated to suggest that cognitive processes, such as attending to food and encoding and retrieving memories of recently eaten foods, play an important role in appetite via influences on meal size and the

intermeal interval (6, 7). This raises the possibility that “attentive-eating” interventions targeting these cognitive processes could be effective in helping weight loss without the need for effortful calorie monitoring. For example, avoiding distraction and increasing awareness of food as it is eaten (8, 9), alongside simple recall of foods eaten at the last eating occasion, would be predicted to decrease food intake at the next eating opportunity (10). One theory is that such processes serve to enhance episodic memory representation of food consumed, which is used to inform subsequent decisions about how much to eat (7, 10).

Other cognitive weight-loss strategies already exist, such as mindfulness training, slow eating, and promotion of food habituation, but we suggest that these may be in part effective because they incorporate aspects of what we call “attentive eating.” Mindfulness training is centered on techniques and exercises that bring about a willingness to experience difficult thoughts, feelings, and sensations rather than trying to avoid or control them (11). Hence, adopting a more mindful approach to eating might feasibly reduce distraction from negative emotions and avoidance behaviors that would normally prevent attentive eating. Similarly, slow eating and habituation strategies that have been reported to reduce energy intake and support weight loss (12–14) may increase attention paid to food and enhance encoding of food memories by increasing exposure to food stimuli. However, these approaches may have additional effects such as enhanced self esteem in the case of mindfulness therapies, increased external control of eating in the case of slow eating interventions, and limitation of the diet in habituation approaches (11, 12, 14).

Our focus here is on studies that have manipulated attention to food while it is eaten and altered memories of previously eaten

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food and then examined the effect on food intake. We conducted a systematic review and meta-analyses. Our aim was to assess whether there is sufficient evidence to inform the development of behavioral interventions for weight loss centered specifically on attentive eating. We also examined moderators of attentive-eating effects on food intake and evaluated the proposition that attention and memory manipulations influence eating via changes in episodic meal memories.

SUBJECTS AND METHODS

Eligibility criteria

Participants

Studies with neurologically intact adults (≥ 18 y of age) were included.

Intervention/studies

Studies examining the effect of manipulating distraction, memory, awareness, or attention on food intake and food memory were included.

Comparator/control groups

To be eligible for inclusion, all experiments were required to include a control condition.

Outcome measure

Studies were required to measure food intake assessed as either energy intake or quantity of food consumed.

Study design

Only studies with experimental designs were included, and both within-subjects and between-subjects designs were suitable for inclusion.

Information sources and search strategy

The main search strategy was to search 4 electronic databases: Ovid PsycINFO (<http://www.apa.org/pubs/databases/psycinfo/index.aspx>), Medline (<http://www.nlm.nih.gov/pubs/factsheets/medline.html>), Embase (http://www.embase.com/Web_of_Science), and Web of Science (http://thomsonreuters.com/products_services/science/science_products/a-z/web_of_science/). Searches took place during February 2012. Searches included a combination of key words and Medical Subject Headings relevant to diet, food intake, appetite, eating behavior and memory, distraction, concentration, awareness, and attention. For the full search strategy used, *see* "Supplemental data" in the online issue. Search limiters included human subjects and studies reported between 1995 and 2012, based on the authors' knowledge of the earliest reported relevant studies. These electronic searches were supplemented by a manual search of reference sections in articles identified by the electronic search and other relevant sources. The search process was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)⁵

guidelines (15). *See* "Supplemental data" in the online issue for the PRISMA checklist.

Quality assessment

To be eligible for inclusion, a control group had to have been used and as most of the studies reviewed had to be laboratory experiments (all of which were conducted blind and had a follow-up of close to 100%); the usual quality filters for randomized trials or observational epidemiologic studies did not apply. However, we examined whether studies used designs that meant participants would be unlikely to have become aware of the true purpose of the experiments, because this may have influenced conscious decisions made about consumption. We further examined whether participants reported awareness of the study aims.

Extraction of data

One author (ER) performed the electronic searches and was responsible for the evaluation of articles for inclusion. All authors were responsible for suggesting relevant additional articles.

Data items extracted for individual studies

Participant characteristics

We extracted sample size, population, age, BMI, and any exclusion criteria.

Intervention/study

We recorded the research topic examined by the study (eg, distraction on food intake), experimental procedure, and how, when, and what type of food intake was measured.

Comparator/control group

We recorded the procedure for the control group.

Outcome measure

We extracted the mean and SDs of food intake (grams of food, kcal) for experimental and control conditions for meta-analyses.

Study design

We recorded the study design, whether it was within-subjects or between-subjects, laboratory or nonlaboratory based, and the schedule of experimental sessions.

Synthesis of results

Meta-analysis

We combined studies using an inverse variance meta-analysis with Revman version 5.1, calculated the weighted standardized mean difference (SMD) between experimental and control groups and its 95% CI, and assessed heterogeneity with the I^2 statistic. Five study types were identified, which were distraction on immediate intake, distraction on later intake, memory enhancement on later intake, reduced awareness on immediate intake, and increased awareness on immediate intake. We calculated SMDs for each of these subgroups and compared the

⁵Abbreviations used: GRADE, Grading of Recommendations Assessment, Development and Evaluation; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SMD, standardized mean difference.

effect of distraction on immediate and later intake formally using a chi-square test for difference between subgroups. A positive SMD indicates that the experimental group ate more than the control group ate. A negative SMD indicates that the experimental group ate less than the control group ate. The larger the SMD, the bigger the difference between the control and the experimental groups.

Most studies included one experimental condition and one control condition and so contributed one comparison to the analyses. Some studies included more than one experimental condition. For example, Bellisle and Dalix (16) examined the effect of television and radio (separately) compared with that of the control. Thus, in this example, this single study contributed 2 comparisons to the analyses (television compared with control, radio compared with control). For these types of comparisons, as is standard, we divided the number of participants in the control condition by the number of experimental conditions. Some studies used within-subjects designs, for which the participant experienced both intervention and control conditions and acted as their own control. We entered these into the analysis as though they were between-subjects studies.

When the heterogeneity of the effects was found, we examined whether this was due to outlying studies by excluding them from the meta-analysis. If there was still appreciable heterogeneity, we calculated the random-effects weighted mean difference.

We investigated the effect of 2 moderating variables (disinhibition and restraint), which was based on the moderators investigated in the literature we reviewed. *Disinhibition* refers to a tendency to overeat as a consequence of external cues or emotion, whereas *restraint* refers to deliberate dietary restriction, typically to avoid weight gain or with a view to eating healthily (17). We analyzed the data in subgroups defined by high and low disinhibition and restraint using the cutoffs given in the studies.

Quality of studies and recommendations

We assessed the quality of evidence using the Grading of Recommendations Assessment, Development and Evaluation

(GRADE) system (18). In particular, for each group of studies we assessed the study limitations, consistency of results, and directness of evidence. This resulted in evidence being categorized as very low, low, moderate, or high in quality. See the GRADE system for more information regarding classification and recommendation criteria (18). A review protocol was not registered before conducting the review.

RESULTS

Study selection

Initial electronic search results produced 637 possible articles, of which 63 were identified for full assessment and 47 were excluded because they had not examined memory, distraction, awareness, or attention and food intake in adults ($n = 40$), did not measure food intake ($n = 3$), did not include an adequate control condition ($n = 3$), or reported inadequate information about food intake for data extraction ($n = 1$). Three more articles were identified and included through searching reference lists found in the electronic search. Some articles reported multiple studies that met the inclusion criteria. Thus, a total of 19 articles reporting on 24 suitable studies were included (Figure 1; PRISMA flow chart).

Overview

Participant characteristics

The sample BMI was available for 19 of 24 studies, 18 of which included participants with a mean BMI (in kg/m^2) in the healthy range (18.5–24.9) and 1 of which included a participant with a mean BMI in the overweight range (25.8). Age was available for 21 of 24 studies, the mean age was 21.8 y (range: 20–47 y). Fifteen of the 24 studies reported some form of participation exclusion criteria, which typically involved current use of medication or medical treatment.

Intervention/study type

Studies were classified into 5 main types: studies examining the effect of distraction on immediate intake (Table 1), studies

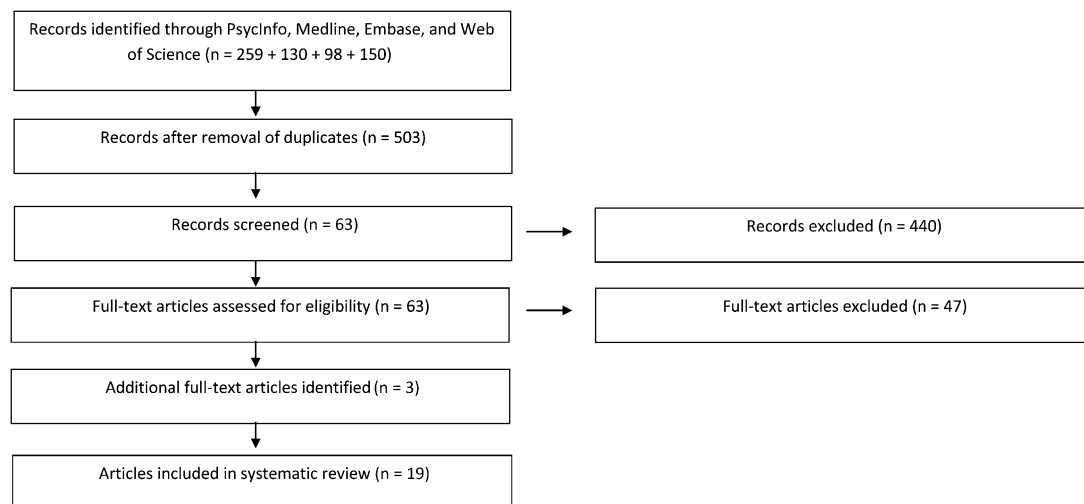


FIGURE 1. Literature search process guided by Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. PsycInfo (<http://www.apa.org/pubs/databases/psycinfo/index.aspx>), Medline (<http://www.nlm.nih.gov/pubs/factsheets/medline.html>), Embase (<http://www.embase.com/>), Web of Science (http://thomsonreuters.com/products_services/science/science_products/a-z/web_of_science/).

TABLE 1
Studies that examined the effects of distraction and increased attention on immediate intake

Authors	Participants and exclusion criteria	Study type and schedule	Food intake measure	Experimental conditions
Bellisle and Dalix, (16) 2001 ¹	<i>n</i> = 41 Adult females Mean age = 35.0 y Mean BMI = 21.3 kg/m ² Eligibility = aged 18–60 y, no declared pathology or current medical treatment	Repeated-measures design; 4 experimental sessions with 1 wk between sessions	Laboratory ad libitum lunch meal intake measured during sessions	4 conditions: during sessions, lunch eaten in presence of others, while listening to recorded radio drama (distraction), or while listening to recorded instructions focusing attention on food alone (increased attention) or alone (control)
Bellisle et al, 2004 (19)	<i>n</i> = 48 Adult females Mean age = 29.9 y Mean BMI = 22.3 kg/m ² Eligibility = 18–50 y, normal weight, no current medical treatment	Repeated-measures design; 4 experimental sessions with 1 wk between sessions	Laboratory ad libitum lunch meal intake measured during sessions	3 conditions: during sessions, lunch eaten alone (control: first and fourth sessions), while watching television, or while listening to recorded radio drama
Bellisle et al, 2009 (20)	<i>n</i> = 20 Adult females Mean age = 24 y Mean BMI = 22.0 kg/m ² Eligibility = normal weight, no declared pathology or pregnancy	Repeated-measures design; 5 experimental sessions with 1 wk between sessions	Laboratory ad libitum lunch meal intake measured during sessions	5 conditions: during sessions, lunch eaten alone (control), with group of 3 other participants (not included in analysis), alone while watching television, alone while watching television food advertisements, or alone while listening to recorded radio drama; additional factor of participant restraint status (high compared with low restraint) was examined
Blass et al, 2006 (21)	<i>n</i> = 20 Undergraduate male (<i>n</i> = 5) and female (<i>n</i> = 15) psychology students Mean age = not reported Mean BMI = 24.3 kg/m ² Eligibility = not reported	Repeated-measures design; 2 experimental sessions with 1 wk between sessions	Laboratory ad libitum lunch or evening meal intake measured during experimental sessions	2 conditions: during sessions, lunch or evening meal consumed while watching television or listening to music (control)
Boon et al, 1997 (22) Experiment 1	<i>n</i> = 55 Female university students Mean age = 21.4 y Mean BMI = 22.4 kg/m ² Eligibility = not reported	Between-subjects design; single experimental session	Laboratory ad libitum snack intake measured in morning or afternoon during experimental session	2 conditions: meal consumed while listening to a radio program or while alone with no radio program (control); additional factor of participant restraint status (high compared with low restraint) was examined
Boon et al, 1997 (22) Experiment 2	<i>n</i> = 49 Female university students Mean age = not reported Mean BMI = not reported Eligibility = not reported	Between-subjects design; single experimental session	Laboratory ad libitum snack intake measured in morning or afternoon during experimental session	2 conditions: meal consumed while listening to a radio program or while eating alone with no radio program (control); additional factor of participant restraint status (high compared with low restraint) was examined

(Continued)

TABLE 1 (Continued)

Authors	Participants and exclusion criteria	Study type and schedule	Food intake measure	Experimental conditions
Boon et al, 2002 (23)	$n = 122$ Female university students Mean age = 21.2 y Mean BMI = 21.9 kg/m ² Eligibility = not reported	Between-subjects design; single experimental session	Laboratory ad libitum snack intake measured in morning or afternoon during experimental session	2 conditions: meal consumed while listening to a radio program or while eating alone with no radio program (control); belief about food: participants led to believe that snack food was high or low in calories; additional factor of participant restraint status (high compared with low restraint) was examined
Hetherington et al, 2006 (24)	$n = 37$ Males ($n = 21$) and female ($n = 16$) university staff and students Mean age = 28.3 y Mean BMI = 23.9 kg/m ² Eligibility = good health, no allergies, no medication being taken	Repeated-measures design; 4 experimental sessions ≥ 3 d apart with ≤ 2 sessions/wk	Laboratory ad libitum lunch meal intake measured during experimental session	4 conditions: during sessions, lunch consumed while alone (control), while watching television, while with unfamiliar others, or while with familiar others (neither social conditions included in analysis)
Long et al, 2011 (25) ¹	$n = 27$ Young female university students Mean age = 21.1 y Mean BMI = 23.8 kg/m ² Eligibility = no eating pathology history, no current medication with exception of oral contraceptive	Repeated-measures design; 3 experimental sessions with 1 wk between sessions	Laboratory ad libitum lunch or evening meal intake measured during experimental session	3 conditions: during sessions, lunch or evening meal consumed while alone (control), while listening to audio instructions to attend to sensory characteristics of food (increased attention), or while listening to a recorded radio play (distraction)
Martin et al, 2009 (26)	$n = 48$ Male ($n = 22$) and female ($n = 26$) adults Mean age = 31.9 y Mean BMI = 25.8 kg/m ² Eligibility = no medication affecting body weight, no chronic disease, no smokers, refusal to eat study food, irregular menstrual cycle	Repeated-measures design; 4 experimental sessions (2 at lunch and 2 at evening meal) completed during 2 consecutive days (4.5-h gap between lunch and evening meal)	Laboratory ad libitum lunch intake measured during experimental session	4 conditions: during sessions, lunch or evening meal consumed while alone (control), while reading, while watching television containing food advertisements, or while watching television containing no food advertisements

¹ The study tested both distraction and increased attention on intake.

TABLE 2
Studies that examined the effects of distraction on later intake

Authors	Participants and exclusion criteria	Study type and schedule	Food intake measure	Experimental conditions
Higgs and Woodward, 2009 (8)	<i>n</i> = 16 Young female university students Mean age = 19 y Mean BMI = 21.7 kg/m ² Eligibility = no participants outside of normal weight range	Repeated-measures design; minimum of 2 d between 2 experimental sessions	Fixed laboratory lunch consumed before afternoon experimental session with measurement of later ad libitum afternoon snack intake	2 conditions: fixed laboratory lunch consumed while watching television or fixed laboratory lunch consumed in absence of television (control)
Mittal et al, 2011 (27) Experiment 1	<i>n</i> = 32 Females based at university Mean age = 20.8 y Mean BMI = 21.5 kg/m ² Eligibility = English speaking only, no history of diabetes or eating condition, no dieting in preceding 3 mo, no participants outside of normal weight range (BMI = 18–25 kg/m ²)	Between-subjects design; single experimental session	Fixed laboratory snack food consumed during morning; ad libitum lunch intake measured 1 h later	2 conditions: fixed laboratory snack consumed while watching television or fixed laboratory snack consumed in absence of television (control)
Mittal et al, 2011 (27) Experiment 2	<i>n</i> = 84 Females based at university Mean age = 21.3 y Mean BMI = 21.3 kg/m ² Eligibility = not reported	Between-subjects design; single experimental session	Fixed laboratory snack food consumed during morning; ad libitum lunch intake measured 1 h later	4 conditions: fixed laboratory snack consumed in absence of television (control), while watching funny television program, while watching sad television program, or while watching boring television program
Oldham-Cooper et al, 2010 (28)	<i>n</i> = 44 Men (<i>n</i> = 22) and women (<i>n</i> = 22) Mean age = 27.2 y Mean BMI = 23.4 kg/m ² Eligibility = meat eaters only	Between-subjects design; single experimental session	Fixed laboratory lunch consumed; ad libitum laboratory afternoon snack intake measured 2 h later	2 conditions: fixed lunch consumed while completing distracting card sorting game or lunch consumed with no distracting game (control)

TABLE 3
Studies that examined the effects of decreasing awareness of food being eaten on immediate intake

Authors	Participants and exclusion criteria	Study type and schedule	Food intake measure	Experimental conditions
Kennedy-Hagan et al, 2011 (29)	<i>n</i> = 118 Male (<i>n</i> = 16) and female (<i>n</i> = 102) faculty and university staff Mean age = 47 y Mean BMI = not reported Eligibility = not reported	Between-subjects design outside of laboratory; session lasted 2 d	Snack intake (from bowl of pistachio nuts placed on desk) measured over 2 d in workplace; food measured at end of each day	2 conditions: awareness of food eaten reduced (pistachio nut shells removed from desk every 2 h) or pistachio nut shells not removed from desk (control)
Scheibehenne et al, 2011 (30)	<i>n</i> = 96 University students and local community (51 females, 45 males); mean age = 24 y Mean BMI = 22.9 kg/m ² Eligibility = not reported	Between-subjects design outside of laboratory; single experimental session	Lunch intake measured from fixed lunch in restaurant settings	2 conditions: awareness of food eaten reduced (dark restaurant area) compared with control condition of awareness not reduced (normal lighting)
Wansink et al, 2005 (31)	<i>n</i> = 54 Male (<i>n</i> = 39) and female (<i>n</i> = 16) university students Mean age = 22.5 y Mean BMI = 24.9 kg/m ² Eligibility = not reported	Between-subjects design; single experimental session	Ad libitum laboratory lunch intake measured	2 conditions: awareness of food consumed reduced (refilling soup bowl) or normal soup bowl (control)
Wansink and Payne 2007 (9)	<i>n</i> = 50 Postgraduate male (<i>n</i> = 16) and female (<i>n</i> = 34) students Mean age = 24.1 y Mean BMI = not reported Eligibility = not reported	Between-subjects design outside of laboratory; single experimental session	Ad libitum evening snack buffet intake measured in sports bar	2 conditions: buffet consumed with decreased awareness of food being consumed (used plates removed from table) or buffet consumed without removal of plates (control)

TABLE 4
Studies that examined the effects of enhancing memory on later intake

Authors	Participants and exclusion criteria	Study type and schedule	Food intake measure	Experimental conditions
Higgs et al, 2002 (10) Experiment 1	<i>n</i> = 20 Undergraduate female university students Mean age = not reported Mean BMI = not reported Eligibility = no restrained eaters	Between-subjects design; single experimental session	Ad libitum snack intake measured in afternoon laboratory session	2 conditions: before snack eating participants instructed to write about lunch food eaten earlier in day (memory recall) or instructed to write about anything (control)
Higgs et al, 2002 (10) Experiment 2	<i>n</i> = 23 Undergraduate female university students Mean age = not reported Mean BMI = not reported Eligibility = no restrained eaters	Between-subjects design; single experimental session	Ad libitum snack intake measured in afternoon laboratory session	3 conditions: before snack eating participants instructed to write about lunch food eaten earlier in day (memory recall), lunch food eaten the previous day (control), or about anything (control)
Higgs et al, 2008 (32) Experiment 1	<i>n</i> = 14 Undergraduate male university students Mean age = 21 y Mean BMI = 22.5 kg/m ² Eligibility = no diabetes, food allergies, cigarette smoking, BMI outside normal range	Repeated-measures design; 2 experimental sessions with 3–7 d between sessions	Ad libitum snack intake measured in afternoon laboratory session	2 conditions: prior to snack eating participants instructed to write about lunch food eaten earlier in day (memory recall) or lunch food eaten on the previous day (control)
Higgs et al, 2008 (32) Experiment 2	<i>n</i> = 73 Undergraduate female university students Mean age = 20 y Mean BMI = 21 kg/m ² Eligibility = no diabetes, food allergies, cigarette smoking, dislike of test food, BMI outside normal range	Between-subjects design; single experimental session	Ad libitum snack intake measured in afternoon laboratory session	2 conditions: prior to snack eating participants instructed to write about lunch food eaten earlier in day (memory recall) or lunch food eaten the previous day (control); additional factor of trait eating disinhibition of participants (high or low) was examined
Higgs et al, 2008 (32) Experiment 3	<i>n</i> = 46 Undergraduate female university students Mean age = 22 y Mean BMI = 22.0 kg/m ² Eligibility = no diabetes, food allergies, cigarette smoking, BMI outside normal range, nonhabitual breakfast eaters	Mixed design; 2 experimental sessions attended on separate days: on 1 day 1 h after consumption of set lunch, on other day 3 h after consumption of set lunch; sessions occurred on separate days, 3–7 d apart	Ad libitum snack intake measured in afternoon laboratory session	2 conditions: before afternoon snack eating in sessions participants instructed to write about lunch food eaten earlier in day (memory recall), or journey to campus (control); additional factor = trait eating disinhibition of participants (high or low)

(Continued)

TABLE 4 (Continued)

Authors	Participants and exclusion criteria	Study type and schedule	Food intake measure	Experimental conditions
Higgs and Donohoe, 2011 (33)	n = 29 Undergraduate female university students Mean age = 20 y Mean BMI = 23 kg/m ² Eligibility = not reported	Between-subjects design; experimental session 2 h after consumption of fixed lunch in lunch session	Ad libitum laboratory afternoon snack intake measured in second session	3 conditions: lunch eaten with audio instructions to focus on food (enhanced memory condition), reading newspaper about food (control for food thoughts), or eating alone (control)

examining the effect of distraction during an initial meal on later intake (Table 2), studies examining the effect of decreasing awareness of food eaten on immediate intake (Table 3), studies examining the effect of enhancing food intake memory on later intake (Table 4), and studies examining the effect of increased attention on immediate intake (Table 1). Studies examining the effect of engaging with a distracting stimuli and studies examining the effect of reducing awareness of food intake were analyzed separately because they constituted 2 conceptually distinct types of experiment. For example, the latter tended to reduce awareness through the removal of cues of food eaten (eg, the removal of food wrappers from sight), whereas the former studies manipulated what participants were doing as they ate (eg, watching television). Therefore, these 2 types of study could have different implications for the treatment of weight loss. See Applied relevance in the Discussion.

Comparator/control group

Information about the procedure for the control groups was available in all studies.

Outcome measure

For all studies, exact intake information was available or was made available by the authors on request.

Study design

All 24 studies were experimental designs with control conditions and participants randomly assigned to experimental or control conditions.

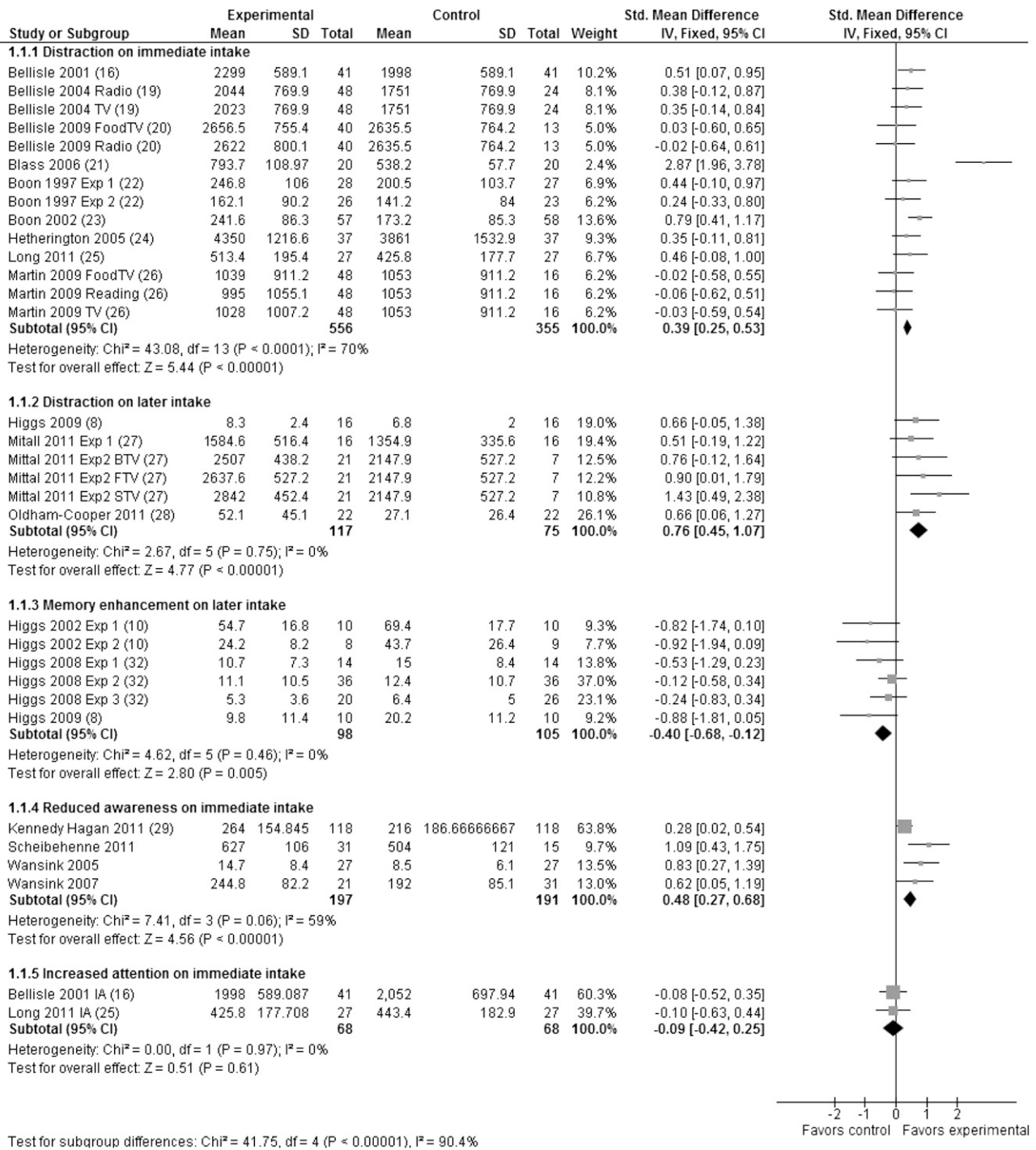
Demand characteristics

Eighteen of the 24 studies used cover stories to ensure that participants were not aware of the study aims. In the remaining 6 studies, this information was not reported. Fourteen of the 24 studies questioned participants on completion of the study to assess awareness of study aims, and all reported that participants were not aware of the true study aims. This information was not reported in the remaining 10 studies. Of the 6 studies not reporting cover stories, 3 reported that participants were not aware of the study aims.

Studies examining effects of distraction on immediate intake

Ten studies examined the effect of a distracting stimulus during an eating episode on food intake during that eating episode, and all took place in the laboratory and measured food intake as lunch or a snack (16, 19–26). Seven studies tested females only (16, 19, 20, 22, 23, 25), and 3 tested men and women (21, 24, 26). Mean BMI was in the healthy range for all studies. The studies examined meal and snack food intake and used a variety of distracting stimuli (eg, television, radio, and reading). The control conditions used in 9 of the 10 studies involved participants eating alone, in the absence of any stimuli that would be likely to be distracting. In one study the control condition listened to music (21), which was assumed not to be visually distracting.





Test for subgroup differences: Chi² = 41.75, df = 4 (P < 0.00001), I² = 90.4%

FIGURE 2. Forest plot of comparisons between the experimental and control conditions for individual study types. BTV, participants watched a boring TV program; Exp, experiment; FoodTV, participants watched a TV program about food; FTV, participants watched a humorous TV program; IA, study included a condition examining increased attention on food intake; IV, inverse variance; Radio, experimental condition listened to a radio play; Reading, participants read a magazine article; Std., standardized; STV, participants watched a sad TV program; TV, participants watched TV.

From the 10 studies, 14 comparisons were entered into the analysis (Figure 2). An overall effect was observed, which suggested that distraction increased immediate intake ($z = 5.43$; $P < 0.001$; SMD: 0.39; 95% CI: 0.25, 0.53; $I^2 = 70\%$) and that there was heterogeneity across comparisons. Heterogeneity was still present after removal of outlying comparison results. Thus, we calculated SMDs using the random-effects weighted mean difference and

found results comparable with the fixed-effects weight mean analysis ($z = 3.01$; $P = 0.003$; SMD: 0.40; 95% CI: 0.14, 0.66).

Studies examining effects of distraction on later intake

Four studies examined the effect of distraction on later intake (8, 27, 28). Mean BMI was in the healthy range for all

studies. Three studies used females only (8, 27) and one used males and females (28). All studies were conducted in the laboratory and typically involved participants consuming a fixed lunch or snack while watching television (distracter) or with no television (control), with later snack or lunch intake measured 2 h later. In all studies the control condition involved participants eating alone, in the absence of any stimuli that would be likely to be distracting. From the 4 studies, 6 comparisons were entered into the analysis (Figure 2). An overall effect was observed, which suggests that distraction increased later intake ($z = 4.77$; $P < 0.001$; SMD: 0.76; 95% CI: 0.45, 1.07; $I^2 = 0\%$); this indicates homogeneity across comparisons.

Studies examining the effect of decreasing awareness on immediate intake

Four studies examined the effect of decreasing awareness of consumption on food intake during eating (9, 29–31). Two studies reported BMI and mean BMI was in the healthy range for both (30, 31). All studies sampled men and women. Studies used very different methods to decrease awareness of food being eaten. For example, a study by Scheibehenne et al (30) removed awareness of food being consumed during lunch by having participants eat lunch in a darkened room and Wansink and Payne's study (9) reduced awareness by removing used plates from the participants' tables in a restaurant buffet setting. The studies examined both snack intake and meal intake. The control condition procedures varied between studies and were dependent on the experimental manipulation used to decrease awareness (Table 1). For example, in the study by Scheibehenne et al (30) the participants ate in a normally lit room and in the study by Wansink and Payne's (9) the participants' plates were not removed during eating.

From the 4 studies, 4 comparisons were entered into the analysis (Figure 2). An overall effect was observed, which suggests that distraction increased later intake ($z = 4.56$; $P < 0.001$; SMD: 0.48; 95% CI: 0.27, 0.68; $I^2 = 59\%$), which indicates a degree of heterogeneity across comparisons. Heterogeneity was still present after removal of outlying comparison results. Thus, we calculated SMDs using the random-effects weighted mean difference and found results comparable with the fixed-effects weight mean analysis ($z = 3.24$; $P = 0.001$; SMD: 0.63; 95% CI: 0.25, 1.02).

Studies examining the effect of increased attention on immediate intake

Two studies examined the effect of increased attention on food intake during eating (16, 25) through the use of instructions (to attend to food during eating). Meal intake was observed during a meal in both studies. The control condition in both studies involved participants eating with no instructions. Both reported BMI and mean BMI were in the healthy range. Both studies included females only. From the 2 studies, 2 comparisons were entered into the analysis (Figure 2). No overall effect was observed, which suggested that increased attention did not influence immediate intake ($z = 0.51$; $P = 0.61$; SMD: -0.09 ; 95% CI: $-0.42, 0.35$; $I^2 = 0\%$), showing homogeneity across comparisons.

Studies examining the effect of enhancing memory on later intake

Six studies examined the effect of enhancing memory on food intake, all of which were reported by Higgs et al (10, 32,

33). Four studies reported that BMI and mean BMI were in the healthy range for all (32, 33). Five studies included females only (32, 33), and one included males only (32). Five studies examined the effect of cueing participants to recall food eaten at lunchtime shortly before an afternoon snack (10, 32). Four of these studies used a control condition in which participants recalled another memory that had occurred that day (eg, a journey). In the remaining study, the only control condition was for participants to recall food eaten at lunchtime from the previous day. Another study examined the effect of enhancing memory through instructing participants to attend closely to food eaten at lunch and then examined later snack intake (33). There were 2 control conditions: 1 group ate with no instructions to attend to their food, whereas the other group was instructed to attend to a magazine article about food. The control groups did not differ significantly in later food intake.

From the 6 studies, 6 comparisons were entered into the analysis (Figure 2). An overall effect was observed, which suggested that distraction increased later intake ($z = 2.81$; $P = 0.005$; SMD: -0.40 ; 95% CI: $-0.12, -0.68$; $I^2 = 0\%$) and homogeneity across comparisons.

The effect of distraction on immediate intake compared with later intake

There was evidence that distraction produced a larger increase on later food intake than it did on immediate food intake ($\chi^2 = 4.5$, $df = 1$, $P = 0.03$).

Moderating variables

There were 3 studies (20, 22, 23) totaling 5 comparisons that allowed for comparison between the influence that distraction has on immediate intake in participants in low compared with high restraint. The analysis indicated no significant difference between the 2 subgroups ($\chi^2 = 0.01$, $df = 1$, $P = 0.92$). There were 2 studies (totaling 2 comparisons) that allowed for comparison between the influence that memory enhancement has on later intake in participants in low compared with high disinhibition. The analysis indicated no significant difference between the 2 subgroups ($\chi^2 = 3.44$, $df = 1$, $P = 0.06$; **Figure 3**). However, the difference in effect size between the 2 groups was substantial. Some evidence indicated that participants low in disinhibition decreased their food intake as a consequence of memory enhancement (SMD: -0.46 ; 95% CI: $-0.93, 0.01$), although this effect did not reach conventional statistical significance ($P = 0.06$). Participants high in disinhibition did not decrease their food intake ($P = 0.4$) (SMD: -0.25 ; 95% CI: $-0.33, 0.82$; **Figure 4**).

Behavioral strategies

We had planned a narrative review of any studies that had developed behavioral strategies based on attentive eating for applied use. However, we found no studies that had tried to apply attentive-eating strategies to free-living populations.

Quality of evidence and recommendations

We used the GRADE approach (18) to assess the quality of evidence supporting conclusions arising from the 5 groups of studies and strength of recommendation for the use of attentive-eating



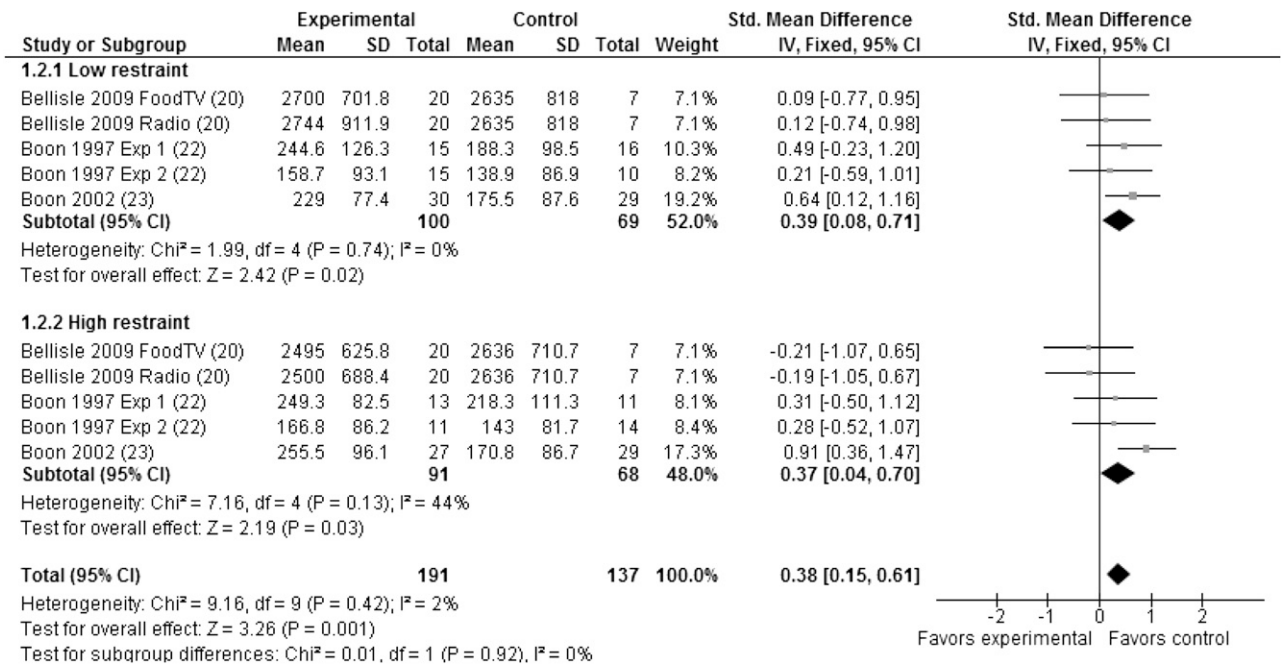


FIGURE 3. Forest plot of comparisons of the effect of distraction on immediate intake between the experimental and control conditions in participants with high or low restraint. Exp, experiment; FoodTV, participants watched a TV program about food; IV, inverse variance; Radio, experimental condition listened to a radio play; Std., standardized.

strategies to aid weight loss. All of the study types included studies that were well designed and methodologically strong. All studies included adequate control conditions and, 21 of 24 used cover stories or provided evidence that participants were not aware of study purposes. We inspected funnel plots of each subgroup for asymmetry of distribution (which may suggest publication bias) and found no evidence of this.

Nine studies examined the effect that distraction has on intake during eating. The effect was consistently replicated, but because some heterogeneity of comparison data were observed, we concluded that the quality of evidence is moderate for distraction increasing immediate intake in laboratory settings. Fewer studies

examined the effect of distraction on later food intake. The study findings were consistent, with a statistically significant increase in later intake observed in the pooled data. Studies were well designed, which increased confidence in the effect. However, because there were only 4 studies reporting on 6 comparisons, we concluded that there is also only moderate current evidence to support the conclusion that distraction increases later intake. Pooled studies that examined the influence that reduced awareness has on immediate intake suggested a statistically significant increase in food intake, which was consistent across all studies. Again, note that the number of studies is relatively small (4), and there was heterogeneity of comparison results. The experimental manipulations were less

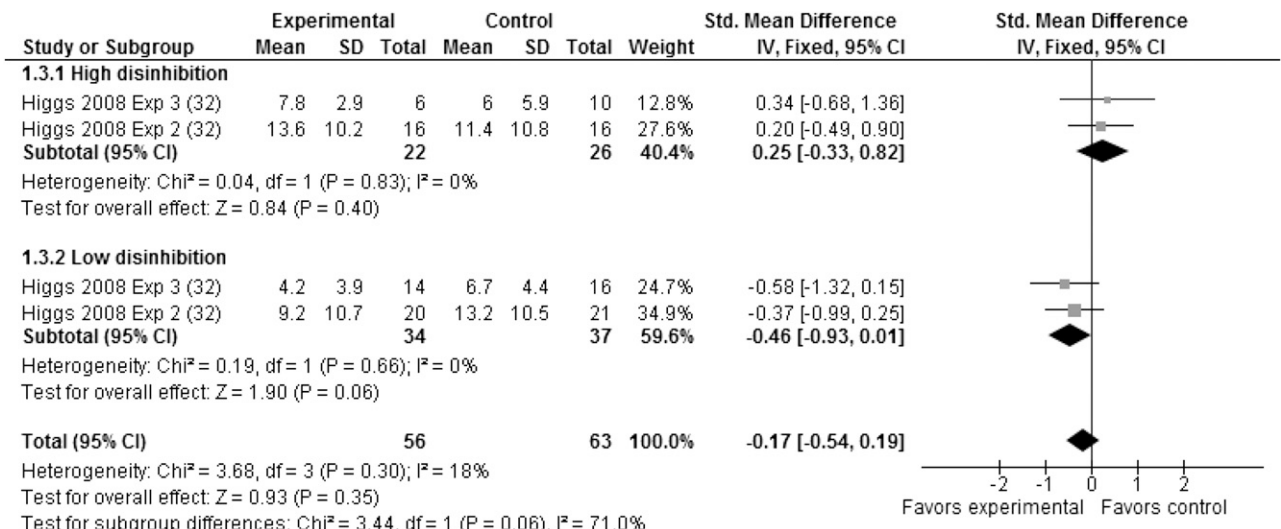


FIGURE 4. Forest plot of comparisons of the effect of memory enhancement on later intake between the experimental and control conditions in participants with high or low disinhibition. Exp, experiment; IV, inverse variance; Std., standardized.

stringent than in other study types; thus, although the results were very consistent, evidence of the effect is moderate. We classified the evidence quality that enhanced memory reduces later food intake as moderate. Six studies that examined this consistently replicated the effect and used stringent controls, but they were all reported by the same group of authors. Finally, we found no evidence that increased attention during eating influences immediate intake when the 2 studies assessing this were pooled or individually. However, this pattern of results may be because participants in the control condition had little else to do and so were already attending closely to their food. Moreover, this conclusion was also based on a very small number of studies; thus, the results should be interpreted with caution. Collectively, the studies reviewed suggest that there is good evidence that attentive eating influences food intake.

DISCUSSION

Overview of main findings

Twenty-four studies were reviewed that investigated the influence of attention and memory on food intake. From these studies, a high-quality evidence base suggests that attentive eating influences food intake. The results suggest that reducing attention via distraction during eating may increase immediate intake, although the size of this effect is smaller than the effect that distraction produces on later consumption. Enhancing memory for food consumed decreases later intake with a medium effect size. Reducing awareness of food consumed was shown to increase immediate food intake, and the size of this effect was large. No effect of increasing attention to food being consumed on immediate intake was observed, although this may have been due to the methods used. Note that the number of studies that each conclusion is based on was variable and in some cases small, although there was consistency in the findings across all study types.

Moderating variables

Only 2 types of moderating variable were appropriate for inclusion in the analyses. Both restrained and unrestrained eaters were shown to increase immediate food intake to a similar extent as a result of distracting stimuli. This suggests that distraction can increase intake regardless of conscious restriction attempts. Some evidence indicated that highly disinhibited eaters were less likely than were participants with low disinhibition to decrease their food intake as a result of memory enhancement. It has been suggested that this may be because such individuals have poorer retention or retrieval of food memory (32).

Eating and episodic memories

The studies reviewed support the hypothesis that memory for food consumed may underlie the observed influence of attentive eating. Results of the pooled memory studies showed that enhancing memory decreases later intake. Within these pooled data, individual studies showed that food intake is reduced by making memory more salient through cueing participants to recall memories of earlier eating (10, 32). A previous study showed that a manipulation to enhance memory representation both improved meal memory and reduced food intake (33). In many studies, the later reduction in food intake as a result of distraction while eating the initial meal was also associated with impaired memory

representation (8, 27, 28), which suggests that memory representation may be the underlying mechanism causing increases to food intake later in the day.

The finding that distraction and reduced awareness increased immediate intake may also be explained through a memory representation account. Both scenarios draw attention away from food, which is likely to impair memory for how much food has been eaten in that meal and lead to overeating. For example, in one study an increase in intake as a result of reduced awareness was associated with a less accurate estimate of the quantity of food eaten (30).

We also found that distraction exerts a greater influence on later intake than it does on immediate intake. This might suggest that distraction has a larger effect on intake as the memory of that eating episode fades. This is consistent with the finding that meal recall only decreased intake a few hours after eating when memory would have faded (32). We suggest that impaired episodic memory for a meal explains why later intake increases as a result of distraction, but other processes should be considered. Distraction can disrupt habituation to the rewarding qualities of a particular food (34), possibly via alterations to associative food memories (35). However, this account seems unlikely to explain distraction effects on later intake, as different types of food eaten were eaten when distracted and later. We also found evidence that the extent to which individuals restrain their intake to avoid weight gain did not moderate the influence that distraction has on immediate food intake. This suggests that distraction may not primarily exert its influence through undermining self-regulatory processes. Taken together this suggests that the effects of distracting stimuli, such as television to increase overall energy intake, are likely more related to effects after rather than during a meal, as is widely thought (36).

There appears to be good evidence that memory processes influence food intake, and this is consistent with evidence that individuals who are unable to form episodic memories due to damage to the hippocampus have a disrupted appetite (37, 38). However, it is not clear what aspects of memory are important. Vividness of memory imagery (33), memory for food eaten (28), and memory of calories consumed (27) were all associated with changes to food intake. One possibility is that in making decisions about eating, people draw on information about the satiating effects of the most recent eating occasion from memory. If the last meal is recalled to be satiating, it has an inhibitory effect on future intake. Using food memories in this way to inform decisions about future food intake allows us to use our wide experience of learning about the satiating effects of foods to predict the consequences of further eating. Meal memories may also be required to interpret internal state cues associated with food ingestion by attributing interoceptive signals to recent eating (32).

Cognitive concepts in appetite control

These findings are important because they highlight a critical role for cognitive processes in eating and the potential for developing new weight-control interventions based on targeting food cognitions. We argue that episodic food memories provide an efficient means of using information about the past physiologic effects of food on the body to predict the consequences of further consumption and avoid the aversive effects of overconsumption. This approach emphasizes the centrality of cognition for human eating but importantly provides a conceptual bridge from the



mechanisms involved in detection and assimilation of nutrients to higher brain regions involved in decision making. This is significant because traditional approaches to appetite control consider physiologic and cognitive controls of feeding as separate rather than fully integrated components of the same system, perhaps because there has been little cross-talk between researchers interested in understanding the physiologic controls of eating and those working on cognitive control. There are also implications for understanding the relations between diet and cognition.

The evidence discussed here, which suggest that food intake is influenced by processes that recruit memory and attention taken alongside an emerging evidence base that Western-type diets can damage brain structures important for learning and memory (39), suggests that the links between cognition and diet are bi-directional. Consumption of a high-fat, high-sugar diet may have detrimental effects on the hippocampus, which has consequences on memory function and appetite control and sets up a vicious cycle to sustain overeating (40).

Clinical use and development of attentive eating

These results suggest that behavioral strategies to encourage individuals to eat more attentively could aid food intake regulation. We found no evidence of studies that had tested the use of attentive-eating strategies in an intervention or in applied settings. The findings suggest 4 principles that may aid intake control on which to base the development of behavioral strategies:

1) Eating devoid of distracting stimuli

Evidence indicates that distraction influences later memory of food consumed and calorie intake, but there may be some practical issues associated with implementing this principle. For example, eating with others could be a source of distraction and has been shown to increase calorie intake in some contexts (19), but there are also benefits to eating with others because family meals are thought to be important in adopting healthy eating habits (41). Instructions to avoid eating while watching television may be more realistic. Because many meal portion sizes are preplanned (42), eating while distracted may not always increase intake during that meal.

2) Prompting memory recall of food previously consumed before eating

Laboratory methods such as cueing memory and enhancing memory reduced food intake in reviewed studies, but practicalities for use outside of the laboratory should be considered. Strategies should be developed that allow for memory recall of earlier food eaten before eating, but that do so in a more convenient way than writing for 5 min about food eaten earlier in the day (10).

3) Being aware of food being consumed and 4) enhancing memory of food consumed

Rehearsal of food eaten or visual prompts of earlier eaten food are strategies that could enhance memory of food consumed. Similarly, instructing individuals to only dispose of food wrappers or other cues of food eaten at the end of an eating episode, and not during, could help to prevent reduced awareness of food being consumed.

Approaches based around these principles may require the development of complex behavioral strategies (43) supported by behavioral-change techniques (44) if they are to be included in a clinical program or form a stand-alone attentive-eating intervention.

Clearly some of these suggestions may require people to behave in ways that might not be natural to begin with, so this will require us to find tools to encourage people to develop these strategies until they become habitual.

Combined approach

An attentive-eating intervention may help people limit their food intake without having to restraint their intake. This may be particularly useful for individuals who are attempting to maintain weight loss. Because the data reviewed here were experimental studies, we know little about the long-term effects of these influences on food intake. However, the effect sizes observed do suggest that, if replicated over time, these findings would have clinical relevance.

Building an evidence base

Because most studies had samples with the mean BMI in the healthy range, it is important to examine whether these effects are observed in people who are overweight (because this is the most clinically relevant population). The numbers of comparisons for some subgroups in the meta-analysis were relatively small, so further studies will be required to increase confidence in the patterns of the results observed. For example, analysis of the effect of distraction on later intake consisted of 4 studies, contributing 6 comparisons. Although we observed large effect sizes and highly significant results in many subgroup analyses, further studies adding to these identified evidence bases are needed. Mechanism testing was limited in the studies reviewed. Studies will now need to unpick underlying causes and provide further evidence of a role of episodic food memories in explaining the results reported here.

Conclusions

Evidence indicates that attentive eating is likely to influence food intake and incorporation of attentive-eating principles into interventions may aid weight loss and maintenance without the need for conscious calorie counting.

The authors' responsibilities were as follows—ER: was responsible for the electronic literature search and data synthesis; ER, SH, and PA: wrote the manuscript; and AD, DL, KJ, and AL: commented on and edited the manuscript. All authors were responsible for suggesting other articles to include in the review and for the final content of the manuscript. None of the authors declared a conflict of interest.

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