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A systematic review and meta-analysis of the social facilitation of eating

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Abstract

Background: Research suggests that people tend to eat more when eating with other people compared with when they eat alone, and this is known as the social facilitation of eating. However, little is known about *when* and *why* this phenomenon occurs.

Objective: This review aimed to quantify the evidence for social facilitation of eating and identify moderating factors and underlying mechanisms.

Design: We systematically reviewed studies that used experimental and non-experimental approaches to examine food intake/food choice as a function of the number of co-eaters. The following databases were searched during April 2019: PsychInfo, Embase, Medline, and Social Sciences Citation Index. Studies that used naturalistic techniques were narratively synthesized, and meta-analyses were conducted to synthesize results from experimental studies.

Results: 42 studies were reviewed. We found strong evidence that people select and eat more when eating with friends compared with when they eat alone ($Z=5.32$, $p< 0.001$, Standardized Mean Difference (SMD)=0.76, 95% Confidence Intervals (CIs)=0.48, 1.03). The meta-analysis revealed no evidence for social facilitation across studies that had examined food intake when participants ate alone or with strangers/acquaintances ($Z=1.32$, $p=0.19$, SMD=0.21, 95% CIs=-0.10, 0.51). There was some evidence that social facilitation of eating is moderated by gender, weight status, and food type. However, this evidence was limited by a lack of experimental research examining the moderating effect of these factors on social facilitation of eating amongst *friends*. In two studies, there was evidence that the effect of social context on eating may be partly mediated by longer meal duration and perceived 'appropriateness' of eating.

Conclusion: Findings suggest that eating with others increases food intake relative to eating alone, and this is moderated by the familiarity of co-eaters. The review identifies potential

mechanisms for social facilitation of eating and highlights the need for further research to establish mediating factors. Finally, we propose a new theoretical framework in which we suggest that the social facilitation of eating has evolved as an efficient evolutionary adaptation.

Keywords: Social facilitation; Social influences; Food intake; Food choice; Meta-analysis

A systematic review and meta-analysis of the social facilitation of eating

1. Introduction

Social factors are important in determining what and how much we eat (1). The tendency for people to eat more when eating in groups than when eating alone is known as the 'social facilitation of eating'. Social facilitation effects have been well-documented across a range of cognitive and physical tasks, and it is thought that the presence of other people potentiates dominant responses (2). In the presence of food, the dominant response is to eat. De Castro and colleagues (3) describe social facilitation as "the most important and all pervasive influence on eating yet identified" (p.100). Given that 77% of adults in the UK eat as a household at least once a week (4), and that a substantial proportion of people's meals are eaten with others (5), it is important to establish *when* and *why* social context facilitates food intake.

Research on the social facilitation of eating examines eating behavior when participants eat in larger or smaller social groups (or alone). Social facilitation effects on eating have been examined using both experimental methods, in which group size is experimentally manipulated, and non-experimental methods, in which eating behavior is examined within real-world contexts. Non-experimental research into social facilitation of eating have gathered

data using self-report (i.e. food diaries/ecological momentary assessment) and researcher-observation methods. Research examining social facilitation of eating has typically used naive volunteers who are free to eat as much or as little as they like, and comparisons are made between the eating behavior (e.g. food intake) of participants eating alone and the eating behavior of participants eating with other people. Some social facilitation studies have also examined associations between the number of people present at a meal and amounts consumed (this is known as the 'social correlation').

There have been two recent narrative reviews of the social facilitation of eating (6,7) . These reviews concluded that the social facilitation of eating is a robust phenomenon, yet the underlying cause(s) remain unclear. A systematic review and meta-analysis of the literature on the social facilitation of eating would build on existing narrative reviews to quantify the size of the effect of social facilitation and formally identify moderators and mediators. In this paper, we present results from a systematic review and meta-analysis that aimed to assess quantitative evidence for the social facilitation of eating and to identify moderating factors. We include both naturalistic and experimental studies which examined food intake or choice as a function of group size in human participants. We also draw conclusions on the current evidence regarding the mechanisms underlying the social facilitation of eating and, in doing so, we identify gaps in the existing knowledge base and provide directions for future research.

2. Methods

2.1. Eligibility criteria

We included studies with human volunteers of any age that had used naturalistic or experimental approaches to examine food intake or food choice as a function of the presence of co-eaters. Experimental studies were excluded if both group size and environmental context were manipulated simultaneously (e.g. examining food intake when participants ate alone in a laboratory context and with others in a cafeteria setting) (8-10). Because social facilitation effects on eating are thought to occur when eating in the presence of other co-eaters (i.e. *not* with passive observers) (11), we excluded studies which examined food intake when participants ate in the presence of others who were *not* eating (e.g. 12). Only studies published in English were included.

2.2. Search strategy

The search strategy was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (13). Relevant studies were identified by searching the following electronic databases during April 2019: PsychInfo, Embase, Medline, and Social Sciences Citation Index. We searched for papers that contained the term 'social facilitation' in addition to either 'food choice,' 'food intake,' 'food selection' or 'eating'. Search limiters included human subjects and studies published in English. These electronic searches were supplemented with a manual search of the citation list of relevant articles. Two reviewers independently screened all search results for their eligibility by examining titles and abstracts. No disagreements were reported. The full text of potentially relevant papers was then screened.

2.3. Quality assessment

Quality checks for randomized control trials and epidemiological studies were not relevant as these approaches were not used in any of the studies identified in the current review. We recorded whether attempts to disguise the study aims were reported (in both experimental and diary/ecological momentary assessment studies), and whether demand awareness was assessed and reported. Funnel plots were inspected to check for publication bias amongst experimental studies that were included in the meta-analysis (supplementary figure 1).

2.4. Data extraction

For each study, we extracted the following information: (1) sample characteristics, (2) design, (3) primary outcome measures, (4) main findings, and (5) whether any moderators or mechanisms were tested or identified. If data required for the meta-analysis (e.g. means and standard deviations) were missing, lead authors on manuscripts were contacted and asked to provide the necessary information. Missing standard deviation values were calculated based on the observed mean difference between conditions and the corresponding *p* value (14).

2.5. Data synthesis

An inverse variance meta-analysis was used to combine the results from experimental studies that had compared food intake when participants ate alone and with other people. Revman (Cochrane) version 5.3.5. was used to calculate the standardized weighted mean difference (SMD) between 'alone' and 'social' eating conditions for each study. A positive SMD indicates that people ate more when eating socially compared with when they ate alone. Confidence Intervals (95%) and I^2 values were also provided to assess statistical heterogeneity. Where high levels of heterogeneity were observed, we calculated the random effects weighted mean difference. Subgroup analyses were conducted to

compare findings from studies that had examined social facilitation when participants ate with their friends with studies that had examined eating with groups of strangers or acquaintances. Standardized mean differences were calculated separately for each subgroup. Some studies compared social facilitation effects across different populations (e.g. in overweight and non-overweight participants) and so these provided more than one comparison to the analysis. For studies that compared food intake when participants ate in larger versus smaller sized groups, mean values were collapsed across all groups.

Owing to the limited number of experimental studies, those that examined the effect of social facilitation on other aspects of eating (e.g. food choice) were narratively synthesized. Similarly, studies that did not include an eat-alone condition, or which used non-experimental methods, were unsuitable for inclusion in the meta-analysis and were therefore narratively synthesized.

3. Results

3.1. Search results

Initial searches identified 263 publications, of which 65 were fully assessed. A further 25 articles were excluded on the following basis: no variation in group size (n=16); did not measure food intake or choice when eating with other people (n=5); did not compare group vs. alone under similar conditions (n=3); and repeated findings from another study (n=1). Two articles (15, 16) each reported two separate studies that met the eligibility criteria, and so 42 studies were included from 40 publications (**Figure 1**). Some studies did not meet the inclusion criteria in the systematic review/meta-analysis but nonetheless provide insight into the moderators and mechanisms involved in social facilitation of eating (12, 17-22). We therefore include these in our wider discussion of the literature.

3.2 Study type

Studies were classified based on the methodology used: 14 used an experimental approach, and 28 used non-experimental methods. Of the non-experimental studies, six studies recorded data using naturalistic observation methods, and 22 used diary or ecological momentary assessment methods. Of the studies that used diary/ecological momentary assessment methods, 13 reported original data and 9 used reanalyzed datasets from previous diary studies. To avoid duplication of data across reanalyzed and original diary studies, reanalyzed datasets were not included when discussing the strength of the effect of social facilitation. Instead, findings from these studies were used only to provide insight into moderators and mechanisms of the social facilitation of eating. An overview of the included studies is presented in **Table 1**.

3.3. Overview of study designs and participants

3.3.1. Experimental research

Across the 14 studies that used experimental approaches, data were collected from a total of 1,004 participants. With the exception of one study (23), all studies reported the mean age of participants. Social facilitation was examined across a range of age groups, including: children (mean age range=4 - 8 years) (24-26), adolescents aged 15-16 years (27,28), older adults (mean age=68 years) (29), and adults (mean age 22-41) (15, 30-35). The majority (n=10) of studies recruited both male and female participants, two recruited females only (30, 31), and two recruited males only (27, 32). Four studies did not report participants' weight status (15, 23, 24, 35), three specifically recruited roughly equal numbers of overweight and non-overweight participants (25, 27, 32), and one study restricted recruitment to non-overweight participants (26). Across the six studies that did not restrict recruitment on the basis of weight status (and which reported Body Mass Index, BMI), the mean BMI ranged from 21 kg/m^2 to 26 kg/m^2.

The majority of studies compared eating behavior when participants ate alone with when participants ate with others (n=12). Two studies did not include an alone condition but compared eating behavior when participants ate in smaller versus larger groups (15, 24). In the majority of studies (n=13), the primary outcome measure was the amount eaten. One study recorded the number of dishes ordered in a mock restaurant scenario (15).

3.3.1.1. Quality Assessment

Nine of the 14 experimental studies reported using a cover story to disguise the aim of the study (15, 23, 25, 26, 31-35). However, only one study reported examining whether participants were aware of the study aims (31). In this study, two participants (out of 120)

179 indicated that they were aware of the aims of the study. Inspection of funnel plots
180 revealed no evidence of publication bias in experimental studies (supplementary figure 1).

181 ***3.3.2. Non-experimental research***

182 *3.3.2.1. Diary/Ecological momentary assessment studies*

183 Across the 13 studies which used diary methods (original datasets only), data were obtained
184 from a total of 5047 participants. The majority of studies (n=12) examined the social
185 facilitation of eating in adults (mean age range 21 - 53 years), and one study examined social
186 facilitation effects in young infants (mean age=13 months) (36). Three studies recruited
187 females only (37-39), and the remaining nine studies included both males and females. Of the
188 studies that examined social facilitation in adults, three did not report the participants' weight
189 status (37,40, 41), one study specifically recruited women with obesity (mean BMI=32 kg/m^2)
190 (39) and one study recruited female participants with underweight (mean BMI=19 kg/m^2) and
191 normal weight (mean BMI=24 kg/m^2) based on Metropolitan Height and Weight tables (38).
192 For studies that did not restrict recruitment on the basis of weight status, the mean BMI
193 ranged from 20 kg/m^2 to 25 kg/m^2. One study specifically recruited participants with treated
194 or untreated bulimia (37), and one study recruited participants with type-1 diabetes (42).
195 Finally, one study (43) specifically recruited representative samples from French (n=26),
196 Dutch (n=50), and American (n=140) populations.

197

198 Nine studies examined data that had been collected in previous research (3, 44-51). The mean
199 age of participants in these datasets ranged from 32 to 44 years, and all studies analyzed data
200 from both male and female participants. In these reanalyzed datasets, the mean BMI of
201 participants ranged from 23 kg/m^2 to 26 kg/m^2. Two studies did not report BMI (3, 45).

202

In studies using diary methods, participants recorded everything they ate, the start and end time of each meal (to determine meal duration), levels of hunger and fullness, and the number of people who were present at each meal. In some studies, participants also recorded their mood (38, 39, 42) and the amount that they intended to eat (16).

Schüz and colleagues (52) used an ecological momentary assessment task in which participants recorded (a) whether other people were eating in their immediate environment (i.e. social eating cues) and (b) the extent to which they felt that eating was appropriate and encouraged. Records were taken whenever participants ate a snack, and at randomly timed prompts throughout the day.

The majority (n=19) of diary/ecological momentary assessment studies (original and reanalyzed datasets) examined eating behavior as a function of group size, and seven compared eating behavior when participants ate alone with when they ate with others (39-41, 44, 51-53). In the majority (n=21) of original and reanalyzed datasets, the primary outcome variable was the calorie content of a meal. Notably, the primary outcome of one study was the probability and amount of meat consumption (41). However, for the purpose of the current review, we also extracted the *total* energy content of meals reported in this study. In one study, the primary outcome was whether a snack was being consumed at each moment of assessment (52). Diary/ecological momentary assessment measures were taken over four (16, 41), seven (36-38, 40, 42, 43, 53, 54), or 14 days (39, 52).

3.2.2.2. Researcher-observed behavior

Researcher-observed behaviors were recorded from a total of 3,600 people and, in every case, both male and female diners were assessed. In three studies, participants' age was estimated: Brindal and colleagues (55) estimated that 83.4% were between 15 and 25 years, Krantz (56)

estimated the median age to be 27-28 years, and Maykovich (57) estimated that their sample was between 30-50 years. Subjects' weight status was estimated in three studies: 69% (57) and 82% (55) of subjects were rated as non-overweight in two of the studies, and another study specifically sought to observe approximately equal numbers of subjects with (n=101) and without (n=96) obesity (56).

Observations were conducted in fast-food and formal dining restaurants (15, 55, 57, 58), and in university or work cafeterias (56, 59). Three studies compared social facilitation effects when subjects ate alone to when they ate in groups (56-58), and four examined the effect of group size on eating behavior (15, 55, 58, 59). The primary outcome variables included the amount eaten (55, 57, 58), the calorie content of foods selected (56, 59), and the number of dishes ordered (15).

3.4. Study findings

3.4.1. Meta-analysis results

Of the 12 experimental studies that included an 'alone' condition, eight reported evidence of social facilitation (23, 25, 26, 29, 31-33, 35). Data from 11 studies (comprising 17 comparisons) that examined food intake when participants ate alone and with others were entered into a meta-analysis. Data from one study were not included due to the pseudo-experimental method used (35). In separate blocks of five consecutive days, participants were asked to eat all of their meals 'only with other people,' 'only alone,' and 'as normal,' and to record everything that they ate during each phase. This study was therefore methodologically different to other experimental research in which group size was manipulated and examined under controlled conditions.

252 The meta-analysis revealed an overall significant effect of social context on food intake,
253 Z=2.57, p=0.01, SMD=0.35, 95% Confidence Intervals (CIs)=0.08, 0.61 (**Figure 2**). A high
254 level of heterogeneity was detected across comparisons (I^2=72%), and the forest plot suggests
255 that stronger social facilitation effects are observed when people eat with friends and family
256 members than when they eat with strangers. We therefore conducted a subgroup analysis in
257 which studies that specifically examined food intake in groups of friends were analyzed
258 separately from studies that tested groups of strangers/acquaintances. Specifically,
259 comparisons from studies that had specifically aimed to recruit groups of people who knew
260 each other were included in the 'friends' subgroup. Comparisons from studies that had
261 examined social facilitation effects in strangers, or which had not attempted to recruit groups
262 of friends, were included in the 'strangers/acquaintances' subgroup. Notably, some
263 comparisons within this subgroup involved participants who were recruited from the same
264 school or workplace and who may therefore have been acquainted (e.g. 27, 28, 32, 34). Of
265 these, one study assessed the degree to which participants knew each other on a 7-point Likert
266 scale (1 = not at all, and 7=extremely) (34). The researchers noted substantial variability in
267 the degree of familiarity between groups (eight groups provided a mean familiarity rating
268 between 1.00-1.99, and five groups provided a mean rating between 6.00-6.99).
269
270
271 *3.4.1.1. Subgroup analysis*

272 Four studies compared food intake when participants ate alone and with friends, and 10
273 studies (contributing 13 comparisons) examined food intake when participants ate alone
274 and with strangers/acquaintances. Subgroup analysis revealed a significant effect of social
275 context across studies that compared food intake when participants ate alone and with
276 friends (Z=5.32, p< 0.001, SMD=0.76, 95% CIs=0.48, 1.03). Specifically, these

277 comparisons revealed greater food intake when participants ate with friends compared to
278 when they ate alone. However, no significant effect of social context was observed in
279 studies which compared food intake when participants ate alone and with
280 strangers/acquaintances (Z=1.32, *p*=0.19, SMD=0.21, 95% CIs=-0.10, 0.51).

281 ***3.4.2. Narrative synthesis***

282 *3.4.2.1. Comparisons between eating alone and eating in groups*

283 In studies using diary techniques, meal size was between 29% and 48% larger when
284 participants ate with others compared with when they ate alone (40, 44, 53). Horgan et al. (41)
285 found that participants ate up to 23 percent more calories when eating with friends, family, or
286 colleagues, relative to when eating alone. Among women with obesity, social meals were
287 29% larger than meals eaten alone (39). Furthermore, using an Ecological Momentary
288 Assessment task, Schüz et al. (52) found that the presence of others eating significantly
289 increased the odds that a measurement occasion represented a 'snack report,' compared with a
290 'random report' (odds ratio=4.18). Two researcher-observed behavior studies found that
291 subjects eating in groups selected or consumed 12% more calories than did those eating alone
292 (56, 58). However, Krantz (56) reported this social facilitation effect only in normal weight
293 subjects; overweight males and females selected 18% *less* food when with others relative to
294 when eating alone (587 vs. 479 kcals). One researcher-observed behavior study found no
295 evidence that subjects eating in groups ate more than those eating alone (57).

296 *3.4.2.2. Moderators of the social facilitation of eating*

297 *Familiarity*

298 The results from our meta-analysis suggest that familiarity with one's dining
299 companion(s) is a significant moderator of social facilitation effects on eating. No effect
300 of eating in a group versus eating alone was observed in studies in which the participants

were eating with strangers/acquaintances, whereas a significant social facilitation effects was observed in the small number of studies that tested people in groups of familiar others (26, 29, 31, 33). These findings are consistent with those obtained from a diary study in which the amount consumed was predicted by group size when subjects ate with friends and family, but not when they ate with (presumably less familiar) co-workers (51).

Gender

One researcher-observed behavior study reported that females ate the same amount as males when in smaller groups (less than 3 people), but ate significantly less than males in larger groups (58). Consistent with that finding, a self-report study found a stronger correlation between meal size and the number of people present in male participants compared with female participants (54). However, experimental studies have reported no significant two-way interactions between gender and social context (23, 25, 28, 34). Notably, these experimental studies did not compare social facilitation of eating in male and female *friends*, and this may have obscured any gender differences.

Berry et al. (23) reported an interaction between food variety and social context that differed between male and female participants. Specifically, both males and females ate more in a group, relative to alone, when they were given one flavor of ice-cream. However, when given three flavors of ice-cream, social facilitation was only observed in female participants.

Two researcher-observed behavior studies reported an interaction between subjects' gender and the gender composition of the group. Specifically, Brindal et al. (55) found that males, but not females, ate more when eating in mixed-sex groups of 3 or more

people, compared with mixed-sex pairs. Similarly, Young et al. (59) found that, for female diners, calorie selection was negatively predicted by the number of males in a group, and positively predicted by the number of females in a group. In contrast, neither group size nor gender composition significantly predicted calorie selection in males. The degree of familiarity between co-eaters in these researcher-observed behavior studies was not reported (55,59).

Dietary restraint/Weight status

Two experimental studies examined social facilitation in high and low restrained eaters (30, 31). Bellisle and colleagues found no overall social facilitation effect and this did not differ according to dietary restraint (30). Clendenen et al. (31) reported social facilitation of eating among familiar participants, but no moderation by dietary restraint. Similarly, a diary study found that the number of people present at a meal predicted food intake irrespective of dietary restraint (49). One study found that the strength of the social correlation did not differ significantly between those with high and low external eating scores (assessed using the Dutch Eating Behavior Questionnaire) (16).

Two researcher-observed behavior studies examined whether the effects of social context on food intake differed as a function of participants' weight status (56, 57). Krantz et al. (56) reported social facilitation effects only in non-overweight subjects, while overweight subjects eating alone selected more calories than did those eating with others. Maykovich (57) reported no effect of social context on the amount of food consumed in non-overweight individuals, while subjects with overweight or obesity ate less when with other people compared to alone. Salvy et al. (25) found that social facilitation effects were only evident in non-overweight children; overweight children ate more when eating alone compared with

when they ate with others. Contrary to these findings, one experimental study reported no effect of social context on eating behavior in normal weight and overweight male adolescents (27). Furthermore, Edelman (32) found that social facilitation effects on eating were not significantly moderated by weight status in male participants. However, the experimental studies described above examined food intake amongst strangers/acquaintances (25, 27, 32); to our knowledge, there has been no experimental examination of the moderating effect of weight status on social facilitation within groups of friends.

Food type

Several diary studies examined whether social facilitation is observed across various meal types. Three found greater social facilitation effects for foods high in fat and/or protein, and lower in carbohydrate (35, 39, 40), and one study (53) reported social facilitation effects across all food types (i.e. across foods high in fat, protein, and carbohydrates). Horgan et al. (41) found that meals consumed with others were more likely to contain meat than meals eaten alone. One experimental study also demonstrated an 18% increased intake when individuals ate with a friend compared with when they ate alone, and the social facilitation effect was particularly enhanced for high-fat sweet food (55%) (33). However, Clendenen et al. (31) found that participants eating in groups four friends did *not* consume more sweet or savory foods than those eating in groups of two. Several experimental studies found no evidence of social facilitation for foods high or low in fat and/or sugar (i.e. casserole, cake, fruit sherbets, pizza, cookies) (27, 28, 30, 34). The null effects obtained in these studies is likely due to the fact that they examined food intake amongst groups of strangers/acquaintances, and not friends.

3.4.2.3. The social correlation

Diary studies have found small to moderate correlations between the number of people present at a meal and meal size in healthy adult populations (45, 16, 37, 39, 40, 42, 43, 47, 48, 49, 50, 54). Heusel and de Castro (38) found a correlation between the number of people present and meal size, and reported that this was true for both healthy weight and underweight women.

De Castro et al. (3) reported a social correlation across both meals and snacks, and in meals consumed with and without alcohol. However, one study found that the social correlation was only evident for snacks and for meals eaten at breakfast; there was no social correlation for meals eaten at lunch and dinner (16). In a reanalysis of existing datasets, de Castro and Brewer (45) reported a non-linear relationship between meal size and the number of people present. Specifically, eating with one other person was associated with 28% larger meal size, relative to eating alone, while eating with 2, 3, 4, 5, and 6 or more people was associated with a 41%, 53%, 53%, 71%, and 76% increase in meal size, respectively.

One researcher-observed behavior study reported a greater number of dishes ordered as a function of increased group size (15). Cavazza et al. (15) also found that the number of dishes ordered in a mock restaurant could be predicted by the size of the group. This was moderated by trait self-monitoring (i.e. the degree to which one is motivated to act appropriately), such that social facilitation effects were only observed for those who scored high on this trait. In contrast, three researcher-observed behavior studies found no effect of group size on the energy content of foods selected (59) or eaten (55, 57). Klesges et al. (58) also reported that females ate less in larger, compared with smaller, groups. One experimental study reported no

effect of group size on intake; participants did not eat more in groups of four compared with pairs (31).

The social correlation has also been investigated in children. One-year-old infants demonstrated a weak correlation (r=.14) between the number of people who were present during feeding and the amount they ate (36). Another study found that, after controlling for snack duration, children ate more when eating in groups of 9 compared with groups of 3 (24). There was also a group size by meal duration interaction such that, for children who ate for longer duration (>11.4 minutes), those in larger groups ate 30% more than did those in smaller groups. For those children who ate for a shorter duration (<11.4 minutes), there was no difference in the amounts eaten when groups of 3 and 9 children were compared (24).

3.4.2.4. Mechanisms

Meal duration

Several studies have examined whether social facilitation effects on eating are explained by a longer meal duration for those eating in groups, relative to those eating alone (or in larger groups relative to smaller groups). Using a diary approach, four studies reported positive correlations between group size, food intake, and meal duration (44, 45, 16, 51). Partially consistent with these findings, one researcher-observed behavior study found that food intake correlated positively with meal duration, but *not* with group size (55). Meal duration also significantly mediated the relationship between group size and food intake (16). In addition, Feunekes et al. (16) reported an indirect effect of group size on intake via participants' ratings of the atmosphere (rated on a 10-point scale from 'unsociable' to 'sociable') *and* meal duration. Interestingly, one study found that the mechanisms by which social context facilitated intake differed between types of companions; specifically, eating with friends and eating with family members facilitated

intake via increased meal *duration* and faster eating *rate* (calories consumed per minute), respectively (51).

Experimental research has uncovered a relationship between meal duration, group size, and food intake. Specifically, Redd and de Castro (35) reported longer meal duration *and* larger meal sizes when participants ate with others, compared to when they ate alone. Furthermore, Clendenen et al. (31) found that participants eating in pairs took significantly longer to eat, and ate more, than did those eating alone and in groups of four (although the amount eaten did not significantly differ between those eating in pairs and groups of four). To directly examine the role of meal duration, one study limited meals to a shorter (12 minutes) or longer (36 minutes) duration when participants ate alone, in pairs, and in groups of four (34). Participants in the longer duration condition ate more than did those in the shorter duration condition, however food intake was not affected by social context.

While the majority of evidence supports the idea that longer meal duration plays an important role in the social facilitation of eating, findings from two experimental studies suggest that extended meal duration is neither necessary nor sufficient for the social facilitation of eating. One study found that, for those who ate for longer duration (i.e. > 11.4 minutes), children in groups of 9 consumed 30% more than did those who ate in groups of 3 (24). Furthermore, Hetherington et al. (33) found a longer meal duration when participants ate with friends and strangers, relative to alone, yet social facilitation effects were only observed when participants ate with friends.

Distraction

Four experimental studies compared the effects of social context and other forms of distracting activities on eating. Three reported increased intake when participants ate while watching TV or listening to a story or to music, relative to when they ate without distraction, but found no evidence for social facilitation (27, 28, 30). Notably, none of these studies examined eating when participants were with friends (instead, participants ate with strangers/acquaintances). In contrast, Hetherington et al. (33) found that participants consumed 18% more food when they ate with friends and 14% more food when they ate while watching TV relative to when they ate alone with no distraction. This increased intake also coincided with the extent that each activity distracted participants away from the lunch meal; participants spent significantly less time looking away from the lunch meal (indicative of less distraction) when eating alone, compared to when watching TV or eating with a friend. However, while eating with friends and strangers distracted participants' attention away from the food to the same degree, increased intake was only observed when participants ate with friends (33).

Mood

Several diary studies examined whether social facilitation effects were attributable to the effect of social context on mood. Three studies reported increased levels of elation and anxiety prior to and after eating with others, compared with eating alone (44, 51, 53), although there was no correlation between group size and an objective measure of arousal (i.e. heart rate) (53). Other findings suggest that levels of elation and anxiety cannot adequately account for the social facilitation of eating. Firstly, de Castro (44) found that differences in elation ratings between meals eaten alone and socially accounted for just 2% of the variance in meal size. Secondly, subjective mood ratings were not significant predictors of meal size

when entered into a multiple linear regression with group size (44, 53). Finally, de Castro (51) reported greater social facilitation when participants ate with friends or spouses, compared to when they ate with co-workers, despite the fact that eating with co-workers was associated with greater levels anxiety and elation.

Norms of appropriate intake

One study examined whether the effects of social context on food intake was due to normative influences (52). Using an Ecological Momentary Assessment task, Schüz et al. (52) reported that the relationship between social context and snack intake was mediated by the extent to which participants perceived eating to be 'encouraged' and 'appropriate'. Across two studies, Cavazza et al. (15) reported that people ordered more food as a function of group size, and that the number of dishes ordered by each individual in a group corresponded highly with the number of dishes ordered by others in the group. This finding provides further evidence for the role of norms as a potential mechanism behind the social facilitation of eating. In their normative perspective of social eating, Herman and colleagues (60) suggest that individuals eating socially generally try to eat as much as possible, without being seen to be eating excessively; that is, they attempt to eat no more than the largest eater in the group. This may lead to positive feedback whereby the larger norm set by one individual 'permits' greater intake of another, and vice-versa. This is consistent with the idea that social eating provides a 'license' to indulge (60).

Food palatability/appetite

One diary study found that the palatability of the meal was associated with the size and gender composition of a group. Specifically, male and female participants rated meals eaten with one female as more palatable than meals eaten with many females, while the number of males was not related to palatability ratings (54). However, Feunekes (16) found that food

palatability did not mediate the relationship between group size and intake. No studies have examined whether social context moderates changes in appetite during the course of a meal, although McAlpine et al. (29) found that when participants ate alone or with others their pre- and post-meal ratings of hunger, fullness, and desire to eat changed to the same extent. This was despite the fact that those who ate in groups consumed 60% more calories than did those who ate alone.

4. Discussion

We found strong evidence that people eat more food when eating with familiar others compared with when they eat alone. Social facilitation was not observed across studies that had examined eating amongst groups of strangers or acquaintances. The effect of social facilitation on food intake (when eating with friends) (d=.76) is considerably larger than that of portion size (d=.45) (61), and is similar to the large effect reported for modelling of eating (d=.85) (62). We find that evidence for the 'social correlation' is weak and that the available evidence provides limited insight into the mechanisms underlying the social facilitation of eating.

4.1. Moderators of social facilitation effects

The majority of experimental studies we reviewed recruited groups of strangers/ acquaintances, and across these studies there was no significant facilitation of eating. However, a significant social facilitation effect was observed across four studies that tested groups of familiar others, and the size of this effect was large (d=.76). In addition, social facilitation of eating was observed consistently across diary studies, which may be due to the fact that the majority of self-selected dining groups likely comprise friends and family. The moderating effect of co-eater familiarity has been alluded to in previous reviews (7; 60) but here we provide the first quantitative evidence for such moderation. It remains unclear whether social facilitation effects on eating are more pronounced in very close friends relative to less close friends, and so this may be an avenue for future research.

We also found some evidence that social facilitation effects are attenuated when women eat in groups that include men (55, 59) and people with overweight/obesity eat with lean people (19, 21, 25, 56, 57). These effects are likely explained by impression management concerns. People are motivated to convey positive impressions to strangers (63, 64) and selecting small portions may provide a means of doing so (6, 62, 65, 66). Impression management concerns

532 are likely to be particularly pronounced for women who are eating with men whom they wish
533 to impress and for people with obesity who are eating with lean dining companions and who
534 wish to avoid negative judgments related to perceptions of overeating (63).
535
536 Social context may specifically facilitate intake of indulgent foods (33, 35, 39) but the
537 moderating effect of food type on social facilitation has not been assessed directly. In
538 addition, De Castro et al. (3) reported social facilitation effects across all meal types, but
539 Feunekes et al. (16) found that the positive correlation between group size and meal size was
540 only significant for meals eaten at breakfast and snacks. Further research is required to
541 establish the robustness of social facilitation effects with different food types and meals.

542 **4.2. The social correlation**

543 Evidence from diary studies suggests a positive correlation between the number of people
544 present and the amount consumed by an individual in that group, but only up to about six
545 people, after which no further increase is observed (45). On the other hand, evidence from
546 researcher-observed behavioral studies and experimental studies is more mixed: some
547 studies find a positive social correlation (15), while others report no effect (31, 55, 58,
548 59). At present, there is not sufficient data to be able to determine how factors such as the
549 degree of acquaintance of the group members may influence the social correlation. It is
550 possible that when a group includes even one member who is less well known to other
551 group members, impression management concerns are heightened, and the size of the
552 social correlation is reduced.

553 **4.3. Mediators of the social facilitation of eating**

554 Only two studies have formally examined the mechanisms behind social facilitation using
555 mediation analyses (16, 52). The results suggest that social facilitation can be partly explained

by longer meal duration (16) and perceptions about the 'appropriateness' of eating (52). However, longer meal duration has been found to be neither necessary nor sufficient for social facilitation (33). Another possibility that has yet to be tested is that social context affects eating via its effects on hunger/food palatability. Ogden et al. (12) found a *positive* relationship between the amount consumed in a social situation and post-meal ratings of hunger, but this study examined intake while participants talked with the researcher (i.e. there was no co-eater). There is evidence that eating in company enhances food palatability (18, 22, 54), but this is yet to be examined as a mediating mechanism of social facilitation.

4.4. Gaps in knowledge and a framework for future research

In order to be able to fully investigate the moderators and mediators of the social facilitation of eating, it will be necessary to minimize the effects of impression management concerns and to conduct studies on participants who are well known to each other.

Previous research has tended to focus on the effect of social context on *immediate* food intake and the effects on longer term intake have yet to be thoroughly investigated. Diary studies have found no correlation between the number of people present at a meal and food intake at a subsequent meal, suggesting that people do not reduce their food intake after consuming a large meal socially (40, 45). However, using survey methods, a recent study found a significant positive correlation between social meal frequency and energy intake for female, but not male, participants (67). Clearly, this issue deserves further investigation because uncompensated social facilitation of eating could play a role in promoting chronic overeating and obesity.

There are several other mechanisms that might promote food sharing and explain why people eat more in groups than they do alone. Eating with others may be more enjoyable,

and the enhanced reward from social eating might serve to increase consumption. Alternatively, social norms might license overeating in company but sanction it when eating alone, and they might encourage greater food sharing because social eating provides an opportunity to consume a larger meal (60). Food sharing might also be promoted if the act of providing food becomes associated with praise and recognition from the social group, thereby strengthening social bonds. Indeed, larger quantities of food are often anticipated and made available (per capita) even before a meal begins (15), a phenomenon referred to as the social 'precilitation' of intake (6).

Finally, and in relation to our question about *why* social facilitation occurs, it may be helpful to dissociate different levels of explanation. Behavioral ecologists sometimes draw a distinction between 'why' and 'how'. 'Ultimate explanations' consider *why* a behavior confers an adaptive advantage, whereas 'proximate explanations' refer to *how* this benefit might be realized (68). For example, omnivores will seek to reduce foraging costs because (why) this reduces the risk of predation. However, the ability to do so (how) is governed by a tendency to find energy-rich food especially rewarding (69). In this review we have focused on plausible proximate mechanisms. However, the underlying (ultimate) reason(s) why social facilitation occurs is rarely considered. As with many other species, humans tend to share a common food resource. However, in humans this is especially true, and many have suggested that hunter gatherers even adopt(ed) an 'active' egalitarian approach to resource distribution (70). Active food sharing probably confers a broader benefit because it protects against periods of food insecurity. A person's day-to-day foraging success is likely to be variable. However, when spread across a group this risk is reduced, and on occasions when a large animal is killed, and when more meat is available than can be consumed by a single individual, it can be distributed before it spoils. Accordingly, in modern hunter-gatherers, meat is not available every day and food

sharing is ubiquitous (70), probably because the cost of sharing is low relative to the benefit from receiving meat from others.

Why then does social facilitation promote an *increase* in food consumption relative to solo eating? First, it is perhaps important to note that the same process has been observed in numerous other species; including; chickens (71,72), rats (73), and gerbils (74). Since social facilitation is conserved across so many species this suggests it serves an ultimate purpose. Although inclusive fitness may be enhanced by strong social collaboration, individuals also compete for resource. Eating more than others is likely to lead to ostracism, which, in turn, reduces food security. Therefore, a tension is created between 'being seen' to engage in altruistic sharing and procuring maximum personal resource. We suggest that when eating socially, a simple solution might be to consume at least as much as others in the group. Hence, social facilitation might occur because individual group members are guided to match their behavior to others, promoting a larger meal than might otherwise be eaten in the absence of this 'social competition'. Although a single meal will have a trivial impact on energy reserves (75), a chronic failure to adopt this strategy (or similar) might have a serious impact on relative fitness. In this way, social facilitation can be viewed as a natural byproduct of social food sharing - a strategy that would have served a critical function in our ancestral environments. The suggestion that social facilitation occurs in response to food sharing also explains why it is confined to individuals who are familiar with each other: food sharing relies on a long-standing reciprocal exchange of food supplies, which is unlikely to occur with strangers.

Of course, most humans are no longer hunter gatherers. Nevertheless, proximate mechanisms that once served efficient foraging continue to guide our dietary behavior (for a review see 76). Indeed, the recent and rapid transition to a dietary landscape in which food is abundant has created forms of 'evolutionary mismatch', whereby these

630 inherited foraging strategies no longer serve their ultimate purpose. In the case of social
631 facilitation, we have inherited a mechanism that ensured equitable food distribution but
632 which now exerts a powerful influence on unhealthy dietary intakes.

633 **4.5. Theoretical and practical implications of research on the social facilitation of eating**

634 Traditionally, social influences on eating have been conceptualized as an independent
635 influence on appetite, separate from the fundamental motivational processes that underpin
636 the control of food choices. However, more recent theorizing on appetite control suggests
637 that social and motivational influences on eating are part of an integrated system in which
638 decisions about what and how much to eat are informed by representations of the value of
639 a particular food item at any one moment and that these representations of value are
640 influenced by beliefs about the nutritional value of foods and many other factors
641 including cultural and social factors (e.g. 77, 78). This theory can be tested by
642 investigating whether eating with others increases amounts consumed via enhancement of
643 the value assigned to food in that context.

644

645 If it turns out that eating socially is a driver of positive energy balance, then this will raise
646 questions about whether avoidance of social eating situations should be recommended for
647 weight control. Social eating is generally considered positive because it may contribute to
648 better interpersonal relations and enhanced well-being. For example, research on family meals
649 suggests that regular eating in a family group is positively associated with well-being (e.g.
650 79). Furthermore, solo eating is often viewed negatively and people report that they would
651 prefer not to do so (80, 81). Hence, advice to eat alone may be neither desirable nor
652 acceptable. An alternative approach would be to suggest strategies that might mitigate

653 overeating so that people can experience the benefits of social eating while avoiding potential
654 effects on weight gain.

655 **4.6. Conclusions**

656 We present the first systematic review and meta-analysis of the social facilitation of eating.
657 Our results suggest that eating with familiar others has a powerful effect to increase food
658 intake relative to eating alone. However, further work is required to assess the moderators and
659 mediators of this effect and the contribution of social eating to positive energy balance. Such
660 research will have important implications for the development of weight management
661 strategies. We argue that future research on the social facilitation of intake might be
662 usefully guided by our new framework, which proposes that social facilitation of eating has
663 evolved as a strategy that ensures procurement of maximum personal food intake in the
664 context of food sharing.

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Authors' contributions:

HR, JB, LV, and SH designed the research. HR conducted the research and analyzed data. HR, JB, LV, and SH wrote the paper. SH had primary responsibility for final content. All authors read and approved the final manuscript.

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Table 1. *Study information and methods of selected studies grouped by study design*

Authors (year)	N	Participant age (M=mean)	Participant BMI (M=Mean) or weight status (NW=Normal weight; OW=Overweight)	Participant gender (M=male; F=female)	Design	Primary outcome variable(s)	Evidence of social facilitation (SF)?	Moderators/mechanisms examined
Experimental studies								
Bellisle (30)	40	M=26	M=22	F	1) eating alone 2) Eating in groups of 3 (unaquainted) 3) listening to detective story 4) Watching TV (no food cues) 5) Watching TV (food adverts)	Amount (g) eaten of main meal and dessert (casserole and fruit sherberts)	No	No moderating effect of dietary restraint.
Berry (23)	126	Not reported	Not reported	M (n=65) + F (n=61)	1) Eating alone + 1 flavor ice-cream 2) Eating alone + 3 flavors of ice cream 3) Eating with others + 1 flavor ice-cream 4) Eating with others + 3 flavors of ice-cream	Amount eaten (ice cream)	Yes	SF observed in both M+F given 1 flavor of ice-cream. SF only observed for F, not M, in p's given 3 flavors of ice-cream.
Cavazza (study 2) (15)	255	M=30	Not reported	M (n=142) + F (n=113)	1) 1 other person, 2) 2 other people 3) 3 other people 4) 4 other people.	Number of dishes selected	Yes	SF only observed in people who scored high on a measure of self-monitoring.
Clendenen (31)	120	M=22	M=21	F	1) Alone 2) in pairs (friends) 3) in pairs (strangers) 4) in groups of 4 (friends) 5) in groups of 4 (strangers)	Amount eaten (deli foods and cookies)	Yes	No moderating effect of familiarity on effect of group size on food intake (excluding 'alone' condition). No moderating effect of dietary restraint. Those eating in pairs and fours ate for longer than those eating alone.
Edelman (32)	53 (46 used in analysis)	M=34	25 OW (>15% height/weight norms; 21 NW (<10% height/weight norms)	M	1) Alone 2) Eating in groups of 4 or 5	Amount eaten (lasagna)	Yes	Moderating effect of weight status did not reach significance.

Hetherington (33)	37	M=28	M=24	M (n=21) + F (n=16)	1) Solo eating, 2) Eating while watching TV 3) Eating with strangers (2 others) 4) eating with friends (2 others).	Amount eaten (buffet lunch). Meal duration. Amount of time spent attending to and looking away from food.	Yes	Familiarity: SF observed when participants ate with friends, not strangers. Food type: SF specifically for high-fat/sweet food. Eating with friends and strangers significantly increased meal duration and time spent looking away from the food, relative to eating alone.
Lumeng & Hillman (24)	54	M=4	Not reported	M(n=37) + F(n=17)	1) Eating in small groups (3 children) 2) eating in large groups (9 children)	Amount eaten (crackers)	Yes – controlling for meal duration	No difference in meal duration between large and small groups
McAlpine (29)	21	M=68	M=27	M(n=2) + F(n=19)	1) eating alone 2) eating with 2 friends	Amount consumed (weight and energy intake) from snacks (sip feed, crisps, cereal bar, chocolate, beer, crackers)	Yes	Changes in hunger, fullness, and desire to eat ratings, prior to and after a meal, were similar in 'alone' and 'with friends' conditions.
Mekhmoukh (27)	38	M=16	Normal weight (M=21; Overweight (M=29).	M	1) Eating alone 2) Eating in groups of 3 3) Watching TV 4) Listening to music	Energy intake from food (casserole, chocolate brownies) and drinks (soda, water, juice)	No	No moderating effect of weight status
Peneau (28)	29	15-16	M=21	M (n=14)+ F(n=15)	1) Watching TV 2) Listening to music 3) Eating alone 4) Eating in groups of 3	Energy intake from food (casserole and cake) and drinks (water, soda, juice)	No	No moderating effect of gender.

Pliner (34)	132	M=41	M=26	M(n=70)+ F(n=62)	1) male/12 min/alone 2) male/36 min/alone 3) female/12 min/alone 4) female/36 min/alone 5) male/12 min/2 people 6) male/36 min/2 people 7) female/12 min/2 people 8) female/36 min/2 people, 9) male/12min/4 people 10) male/36min/4 people 11)female/12 min/4 people 12)female/36min/4 people	Amount eaten (pizza and cookies)	No	No moderating effect of gender. Participants ate more in longer meals, relative to shorter meals, regardless of group size.
Redd & de Castro (35)	30	M=23	Not reported	M(n=10) + F(n=20)	Over 5-day periods, participants instructed to a) eat as they normally would b) eat exclusively alone, and c) to eat only with others present. Participants recorded their food intake.	Self-reported food intake	Yes	Meal type: Fat intake higher in normal vs. alone condition. Within normal condition, fat intake was higher when participants ate with others, relative to when they ate alone.
Salvy (25)	32	M=8	15 NW; 17 OW	M(n=16) + F(n=16)	1) Overweight/alone 2) overweight/in groups of 4 3) normal weight/alone 4) normal weight/in groups of 4	Amount eaten (pizza)	Yes – only for non-overweight participants.	Weight status: Social facilitation observed in non-overweight, and not in overweight, children. No moderating effect of gender.
Salvy (26)	44	M=7	NW only	M(n=20) + F(n=24)	1) alone 2) with sibling 3) with unfamiliar child	Amount eaten (cookies)	Yes – only for children who ate with siblings.	Familiarity: Social facilitation only observed in children eating with siblings, not strangers.
Non-experimental: Diary studies								
Bellisle et al. (54)	26	M=23	M=20	M(n=10) + F(n=16)	For seven days, participants recorded amount eaten and the number of people present at each meal. Levels of hunger and fullness were also recorded before and after each meal.	Calories consumed at each meal (self-reported) and number of people present.	Yes	Stronger correlation between meal size and number of people present in males, relative to females. The authors do not state whether this difference was significant.

de Castro (3)	78	M=32	Not reported	M(n=21) + F(n=57)	Reanalyzed diary datasets	Self-reported meal size, number of people present, whether the record was a meal or snack, eaten with or without alcohol, and eaten at home, in a restaurant, or elsewhere.	Yes	Social facilitation was reported across all meals (breakfast, lunch, dinner) and snacks, eaten at all locations, and consumed with and without alcohol.
de Castro (44)	82	M=32	M=23	M(n=23) + F(n=59)	Reanalyzed diary datasets.	Self-reported meal size, number of people present, meal duration, eating rate, subjective ratings of elation and anxiety.	Yes	Eating rate was unrelated to number of people present. Meal duration was predicted by group size and was associated with the amount eaten. Elation ratings did not predict meal size when controlling for number of people present.
de Castro (47)	762	Age range: 20-34(n=325) 35-49(n=292)) 40-64(n=99) 65+ (n=46).	M=25	M (n=348)+ F (n=414)	Reanalyzed diary datasets	Self-reported meal size (kcals), the number of people present.	Yes	Social correlation did not differ between age groups.
de Castro (48)	315	M=32	M=23	M (n=121) + F (n=194)	Reanalyzed diary datasets	Self-reported meal size (kcals), number of people present, and whether the meal was eaten at the weekend or during the week.	Yes	Social correlation greater for meals consumed at weekends, compared with weekdays.
de Castro (51)	515	M=42	M=25	M(n=276) + F(n=239)	Reanalyzed diary datasets	Self-reported meal size, number of people present, type of companion (friend, family, spouse, co-worker, or other), subjective ratings of elation and anxiety.	Yes	Meals eaten with family/spouse were larger and faster, and meals eaten with friends were larger and of longer duration, compared with meals eaten with others. Anxiety/elation ratings were higher in meals eaten with other people than meals eaten alone. Participant gender x companion gender interaction: females ate more when eating with male companions, than with females. Males unaffected by companion's gender.

de Castro (49)	358	M=44	M=26	M(n=201) + F(n=157)	Reanalyzed diary datasets	Self-reported meal size, dietary restraint (assessed using TFEQ).	Yes	Social facilitation was not moderated by dietary restraint.
de Castro (43)	216 (26 French; 140 American; 50 Dutch)	M=23	M=22	M (n=68) + F(n=148)	For seven days, participants recorded amount eaten, and the number of people (males and females) present at each meal. Hunger ratings were also recorded before and after each meal.	Self-reported meal size	Yes	Correlation between meal size and number of people present similar across all three nationalities (i.e. French, Dutch, American).
de Castro (42)	84 (56 with type-1 diabetes, and 28 healthy controls)	Diabetics: M=53 Healthy: M=49	Diabetics: M=25; Healthy: M=23	M (n=30 with diabetes; n=5 controls) + F (n=26 with diabetes; n=23 controls)	For seven days, participants recorded amount eaten, and the number of people (males and females) present at each meal. Mood and appetite ratings were also recorded before and after each meal, and participants rated the palatability of each meal.	Self-reported meal size	Yes	Social correlation did not differ between diabetic and control participants.
de Castro (50)	265 twin pairs (110 identical twins; 102 fraternal same-sex twins; 53 fraternal mixed-sex twins)	M=40	M=25	M+F	Reanalyzed diary datasets: Self-report data originally collected from 110 identical twins and 102 non-identical (same-sex) twins. An additional 53 mixed-sex twins were recruited for this study.	Self-reported meal size.	Yes	Genetic influences explained 30% of the difference in regression slopes between the number of people present at a meal and meal size.
de Castro & de Castro(40)	63	M=34	Not reported	M (n=14) + F(n=49)	For seven days, participants recorded amount eaten, and the number of people present at each meal. Levels of hunger were also recorded prior to each meal.	Self-reported meal size.	Yes	Meals eaten alone had higher proportion of carbohydrates, and lower proportion of fat, than meals eaten with other people.
de Castro & Brewer (45)	153	M=34	Not reported	M(n=49) + F(n=104)	Reanalyzed diary datasets	Self-reported meal size.	Yes	

de Castro & Taylor (46)	650 (99 smokers; 551 non-smokers)	M=38	M=25	M(n=288) + F(n=362)	Reanalyzed diary datasets	Self-reported meal size, number of people present, smoking status.	Yes	Social facilitation effect stronger in smokers compared with non-smokers.
Elmore & de Castro (37)	52 (19 untreated bulimics; 12 recovered bulimics; 21 controls)	Untreated bulimics: M=22; Recovered bulimics: M=26; Normal eaters: M=26.	Not reported	F	For seven days, participants recorded everything that they ate and drank, and the number of people present at each meal.	Calories consumed at each meal (self-reported) and number of people present	Yes	Social correlation was stronger in healthy controls, compared with those with untreated and recovered bulimia.
Feunekes (study 1) (16)	30	M=22	M=22	M (n=15) + F(n=15)	Participants recorded food consumption, meal duration, no. of others present, relationship to co-eaters, and atmosphere (sociability). Records made over 4 days.	Calories consumed at each meal (self-reported), number of people present, meal duration, and atmosphere.	Yes	Social correlation only observed for meals eaten at breakfast time.
Feunekes (study 2) (16)	20	M=23	M=22	M(n=10) + F(n=10)	Participants recorded food consumed, meal duration, no. of others present, atmosphere (sociability), relationship to co-eaters, and amount intended to eat (small to large amount on 10 point scale). Records made over 7 days.	Calories consumed at each meal (self-reported), number of people present, meal duration, atmosphere, amount intended to eat prior to meal occasion.	Yes	Social correlation only observed for snacks. Across studies 1 and 2, the social correlation was not moderated by external eating score. Meal duration mediated the relationship between group size and food intake.
Heusel & de Castro (38)	99 (33 underweight; 66 normal weight)	Underweight: M=26; Control group 1=35; Control 2=28	Underweight: M=19; NW: M=24	F	For seven days, participants recorded everything they ate and drank, and the number of people present at each meal. They also reported the time of each meal, and their pre-and post-meal ratings of hunger, fullness, depression, and anxiety.	Calories consumed at each meal (self-reported)	Yes	No moderating effect of weight status.

Horgan (41)	4156	M=50 years	Not reported	M+F	For four days, participants recorded everything they ate and drank, as well as the time it was eaten, where it was eaten, and who they were eating with.	Calories and meat (g) consumption at each meal	Yes	
Patel & Schlundt (39)	78	M=37	M=32	F	Participants recorded everything that they ate, and whether other people were present. Participants also recorded their mood at each eating episode. Records were taken over 2 weeks.	Calories consumed at each meal (self-reported), mood, and number of people present.	Yes	No interaction between mood state and social context on intake. Meals eaten socially contained more calories from fat and protein, and less calories from carbohydrates, than meals eaten alone.
Pearcey & de Castro (36)	29	M=13 months	19 infants fell between 5th and 95th percentiles for height and weight for age.	M(n=18) + F(n=11)	Parents recorded everything the infants ate, the number of people present and their relation to the infant, and the beginning and end time of the eating episode.	Calories consumed at each meal (self-reported) and the number of people present,	Yes	
Schüz (52)	61	M=32	M=25	M(n=19) + F(n=42)	Ecological Momentary Assessment task. At randomly timed prompts, and after every time they consumed a snack, participants recorded whether or not there was anyone in their presence who were also eating. Participants also recorded the extent to which they felt that others approved and encouraged them to eat at that moment (i.e. inductive norms). Participants completed the task over 14 days.	Probability of snack consumption vs. random prompt.	Yes	The effect of others eating on snack intake was partially mediated by the perceived approval/encouragement of eating.

Stroebele & de Castro (53)	133	M=21	M=25	M(n=29) + F(n=104)	Over seven days, participants recorded everything that they consumed, the number people present at each meal. Subjective ratings of arousal (i.e. elation and excitement) were also recorded, and physiological arousal was recorded in a subset of participants using heart rate monitors.	Calories consumed at each meal (self-reported), the number of people present, and subjective and objective measures of excitement and elation.	Yes	Social facilitation found for intake of protein, fat, and carbohydrate. Social facilitation was not mediated by ratings of excitement / elation.
Non-experimental: Researcher-observed behavior								
Brindal (55)	157	83.4% rated 15-25; 7.6% rated 26-35; 4.5% rated 36+	82% rated 'not overweight/obese'	M (n=86) + F(n=71)	Subjects observed eating in a fast-food restaurant. Subjects ate in pairs (67.5%), or groups of 3 (19.7%), four (9.6%) or five or more (3.4%). Lone diners were not observed.	Foods eaten, meal duration, and the number of others present.	No	Group size x participant gender x group composition interaction. M in mixed sex groups ate more than M in mixed-sex pairs. F in same-sex groups ate more than those in mixed-sex groups. Amount eaten correlated with meal duration but not group size.
Cavazza (study 1) (15)	1685	Not reported. Excluded children who appeared younger than 13.	Not reported	M(n=793)+ F(n=892)	Subjects observed eating in an Italian restaurant. Subjects ate alone (n=22), in pairs (n=259), or in groups of between 3-30 people (n=228).	Mean number of dishes ordered; mean number of plates with leftovers; average bread and wine consumption	Yes	

Klesges (58)	539	Not reported	Not reported	M(n=294) + F(n=245)	Subjects observed eating in 7 fast-food and 7 formal-dining restaurants. Observers recorded whether subjects ate alone, or in a small (1-3 people) or large (3+ people) group, and the gender composition of each group (i.e. mixed-sex / same-sex). Observers also recorded whether each subject was overweight or normal-weight.	Calories consumed	Yes	Moderating effect of gender. F ate the same as M in small groups, but less than M in large groups.
Krantz (56)	197	Estimated median = 27 - 28	101 rated obese; 96 rated NW.	M(n=106)+ F(n=91)	Students and staff observed eating at a University cafeteria at lunch time. Observers coded participants' gender, and whether or not they ate alone (n=76) or with others (n=121).	Calorie content and number of items chosen.	Yes – only in non-overweight subjects.	Moderating effect of weight status - only non-overweight subjects showed SF. OW individuals ate more when alone, than with others.
Maykovich (57)	553	30-50 years	15% obese; 16% OW.	M + F	Observations conducted across 20 restaurants in a large city in N. America.	Amount eaten	No	Overweight and obese individuals ate less when with others than when alone. For normal weight individuals, there was no difference in the amount eaten by those who ate alone vs. those who ate with other people.
Young (59)	469	Not reported	not reported	M(n=210) + F(n=259)	Subjects observed eating at three University cafeterias. Subjects ate alone (n=37), in pairs (n=188), or in groups of three (n=117), four (n=80), five (n=35), or six (n=12).	Calorie content of foods selected.	No	Moderating effect of gender. For F, the number of M in the group negatively predicted intake, & the number of F positively predicted intake. Number of M or F did not predict intake for M.

Legends for Figures

Figure 1. PRISMA search and inclusion flow chart.

Figure 2. Forest plot for experimental studies comparing food intake when participants ate alone and/or in groups.

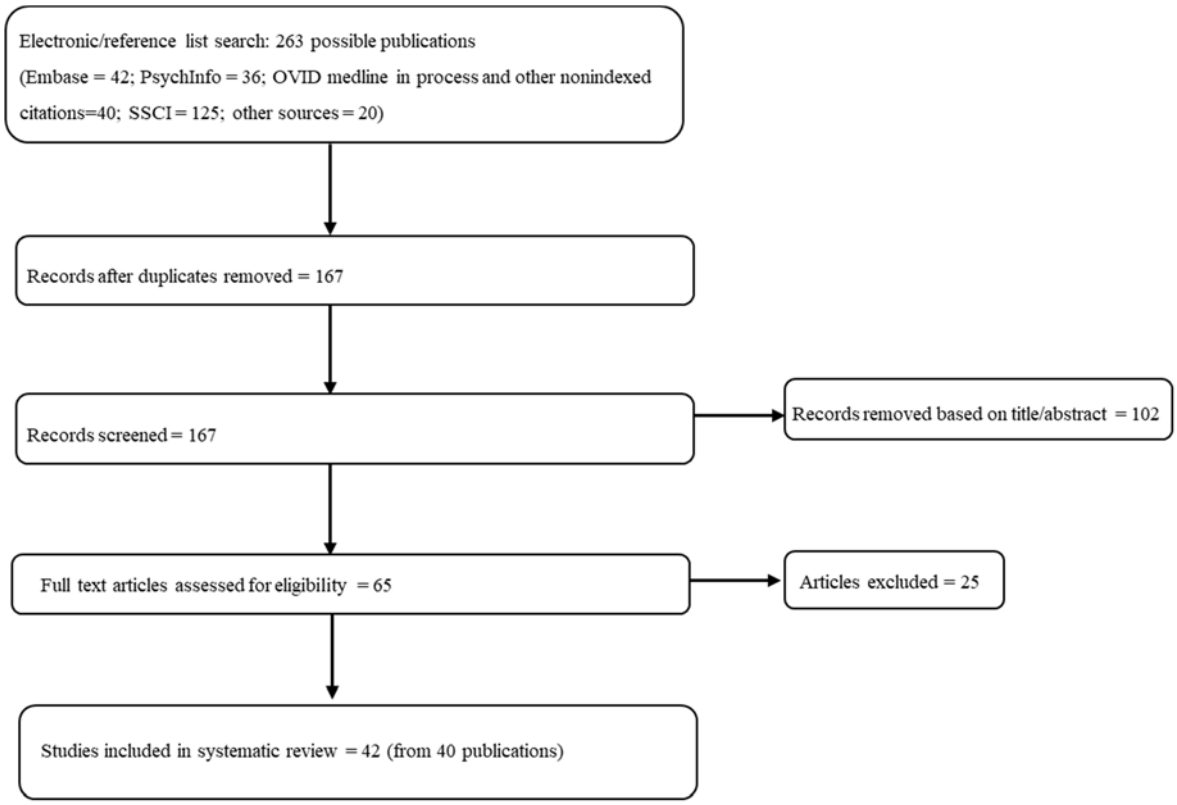


Figure 1.

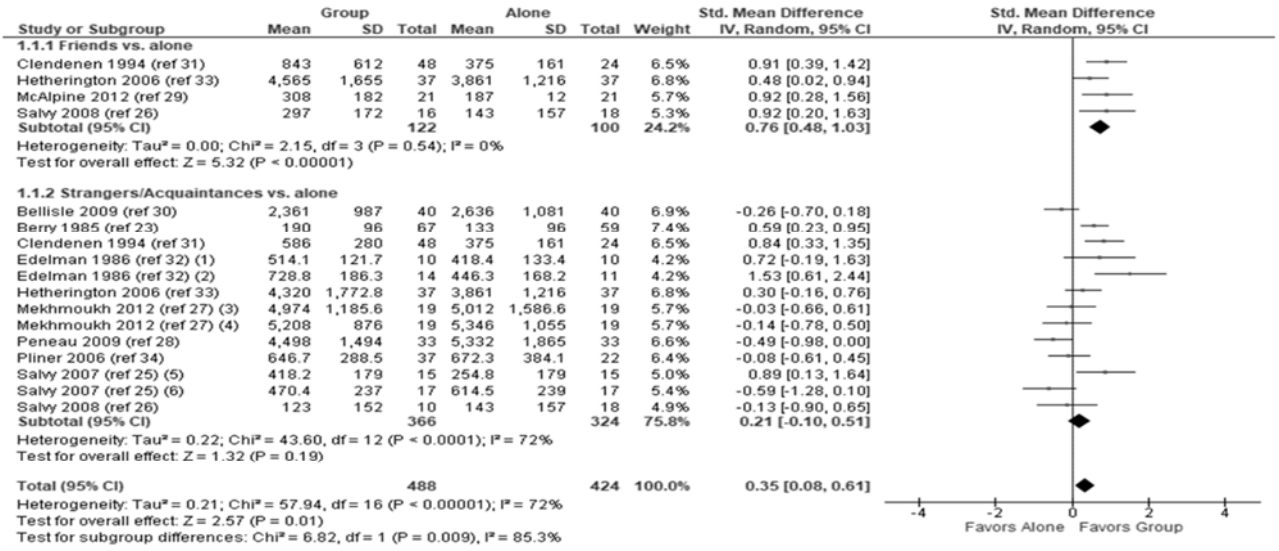


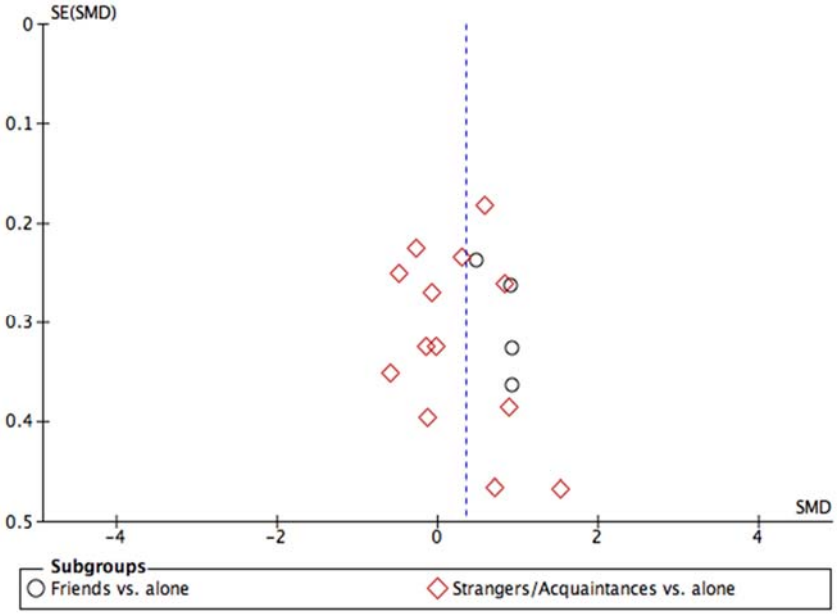
Figure 2.

Notes. Total refers to the number of participants. Studies are grouped based on whether participants ate with friends or with strangers/acquaintances. SD=standard deviation; IV=independent variable; OW=overweight participants; NW=normal weight participants. 1= NW male adults; 2= OW male adults; 3=NW male adolescents; 4=OW male adolescents; 5= NW male and female children; 6=OW male and female children.

Supplementary

A systematic review and meta-analysis of the social facilitation of eating

Helen K. Ruddock, Jeffrey M. Brunstrom, Lenny R. Vartanian, & Suzanne Higgs



Supplementary Figure 1. Funnel plot of effect sizes from experimental studies examining social facilitation effects