Spontaneous meal patterns of humans: influence of the presence of other people\textsuperscript{1,4}

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**ABSTRACT** Social influences on eating were investigated by paying 63 adult humans to maintain 7-d diaries of everything they ingested, time, subjective hunger, and number of people present. Meals eaten with others contained more carbohydrate, fat, protein, and total calories; had smaller deprivation ratios; and had larger satiety ratios than meals eaten alone. The number of people present was positively correlated with meal size even when meals eaten alone were excluded. Adding the number of people present as a factor in a multiple-regression prediction of meal size more than doubled the variance accounted for, without altering the influence of other predictors, suggesting that social factors are associated independently with an increase in meal size. Meal size was positively correlated with the postmeal interval for meals eaten alone but not for meals eaten with other people. This suggests that social factors increase amounts eaten and disrupt postprandial regulation. *Am J Clin Nutr* 1989;50:237–47.

**KEY WORDS** Meals, eating, feeding pattern, intermeal interval, carbohydrate, protein, fat, stomach content, social facilitation, hunger

**Introduction**

It has long been theorized that social factors are a major influence on the eating behavior of humans. They can operate by affecting the time when meals are eaten, as with scheduled family meal times, luncheon appointments, etc (1). They can also alter the amount eaten in a meal by social facilitation, encouragement to eat, modeling, or avoidance of embarrassment or insult (2, 3). Laboratory and observational studies of social effects on the amount and composition of meals have produced mixed results; some found increased meal sizes when other people are present (4) whereas others found smaller meals (5) or mixed results dependent on the nature of the other people present (6). These studies, however, observed eating under very restricted circumstances or in a laboratory setting. There are no data to date on the effects of social factors on the day-to-day intake patterns of humans in their natural environments. Social factors, if they are at all important in the determination of eating, should be apparent in the spontaneous meal pattern of humans in altered timing and sizes of meals. However, because of the difficulty of monitoring of spontaneous food intake in complex social contexts, the exact mode of social effects on spontaneous food intake has not been investigated.

Another reason for interest in the influence of social factors on the meal pattern is to further investigate a species difference in meal patterning. In particular, rats show a postprandial pattern of meal intake. The amount of food ingested in meals is correlated with the amount of time the animal will wait before initiating another meal (postmeal interval) but not with the amount of time that the animal has waited since last eating a meal (premeal interval) (7–12). Humans, on the other hand, show a different pattern. The amount of food ingested in meals is correlated with the duration of the premeal interval but not with the postmeal interval (13–17).

One reason why the difference might occur is that rats are tested in isolated environments under ad libitum conditions. They can initiate eating at any time without social influence. Humans on the other hand are monitored in their natural environments where feeding is often constrained by social conditions. People are often not free to initiate eating whenever they desire food because of the social constraints of family, work, school schedules, etc. According to Bellisle (1), “The principal mech-
FIG 1. Meal characteristics (± SEM). Top: mean amount ingested in meals of carbohydrate (solid), fat (cross-hatched), and protein (hatched) and the food energy estimated to be remaining in the stomach at the time of meal initiation (open) for meals reported to be eaten alone and with other people present. The total energy content of the average meal is equal to the height of the bar at the top of the protein portion of the bar. Bottom: mean deprivation.
anism which allows precise and rapid energetic regulation in animals is thus short-circuited in humans." If humans cannot regulate by adjusting when they eat, it would seem reasonable to regulate by adjusting how much is eaten in a meal. Supporting such an interpretation of the observed species difference is the observation that humans observed in an isolated laboratory environment show a rat-like pattern with significant postprandial correlations and no preprandial correlations (18). There is no evidence to date, however, that the social context is responsible for the spontaneous preprandial eating pattern of humans.

The present study was designed to investigate these hypotheses by using a diary self-report method. The influence of the presence of other people on food intake was investigated by separating meals eaten alone from those eaten with other people and performing separate meal pattern analyses and by correlating the number of other people present at the time of eating with the amount of food ingested in the meal and the premeal and postmeal intervals.

Subjects and methods

The details of the methods used were published elsewhere (16, 17). They will only be summarized here. The protocol was approved by the subjects human committee of Georgia State University.

Subjects

Fourteen male and 49 female subjects recruited from a newspaper ad and by word of mouth were paid $30 to participate. They also received a detailed nutritional analysis based on their food intake for the 7-d reporting period. They averaged 33.6 y (range 19–54 y), 62.8 kg (range 45.5–102.3 kg) and 1.64 m (range 1.48–1.85 m).

Procedure

The subjects were given a small (8 × 18 cm) pocket-size diary and were instructed to record in as detailed a manner as possible every item that they either ate or drank, the time they ate it, the amount they ate, and how the food was prepared. They were also instructed to record their hunger at the beginning of each meal (on a seven-point, full–hungry scale) and the number of people eating with them. The subjects recorded for 1 d and were contacted by the experimenter to review the information, correct any problems, and answer any questions. They then recorded their intake in the diaries for 7 consecutive days. After receiving the diaries, the experimenter reviewed them and contacted the subjects to clarify any ambiguities or missing data in the diary records. The subjects were later contacted by phone if any questions arose about their entries in the diaries.

Data analysis

A computer file of > 3000 food items with assigned code numbers was used. The first step in the data analysis was to convert the foods reported in the diaries into the appropriate computer codes indicating food types and amounts. This was performed by an experienced registered dietitian who was unaware of the experimental hypotheses and did not interact directly with the subjects. The second step in the data analysis was the identification of meals and the summation of the compositions of the individual items composing the meal. For a reported intake to be classified as an individual meal, it had to contain ≥ 50, 100, or 200 kcal. It also had to be at least 15 min before or after other ingestive behaviors. More stringent intervals of 45 and 90 min were also used. Five different definitions of a meal were used combining these minimum criteria, 15 min–50 kcal, 45 min–50 kcal, 45 min–100 kcal, 45 min–200 kcal, and 90 min–50 kcal.

Meals were characterized by their total caloric content; carbohydrate, fat, and protein content; premeal interval; postmeal interval; meal size in kilocalories divided by premeal interval in minutes (deprivation ratio); the postmeal interval in minutes divided by meal size in kilocalories (satiation ratio); self-rated hunger at the beginning of the meal; and estimated premeal and postmeal stomach contents. The caloric content of the stomach was estimated with a computer model described previously (13–17). The reported intake was entered into the model and was estimated to empty from the stomach at a rate proportional to the square root of the caloric content of the stomach in little calories per minute (17, 19–21). The total food energy content of the stomach and the proportion of each macronutrient estimated to be present at the beginning and at the end of each meal was included in the subsequent analyses.

Summaries of the intake characteristics of each individual subject were prepared by calculating means of the meal characteristics across all meals, meals eaten alone, and meals eaten with other people present. Pearson product-moment correlations were calculated for each subject between the reported hunger, the meal characteristics, the intermeal intervals, and the stomach contents (22). They were calculated separately for all meals, for meals that were reported as eaten alone, and for meals eaten with other people present. Correlations were also calculated between the number of people present and the meal characteristics and intervals. Correlations were calculated using all intermeal intervals except the overnight fast. Multiple-linear-regression analyses were also performed on these same data individually for each subject. Regressions were performed separately for all meals, for meals eaten alone, and for meals eaten with other people. Multiple regressions were also performed with the number of people present as one of the independent variables.

Group means and standard errors were then calculated using the meal characteristics, correlations, multiple-regression β (standardized) coefficients, intercepts, and multiple correlations that had been calculated for each subject individually. Analyses of the correlation coefficients were performed on r-to-z transformed coefficients (4). The mean correlations and coefficients were then compared with zero with a t test. Within-group mean correlations, β coefficients, or intercepts were compared with a correlated-groups t test.

Results

Analyses were performed on meals identified by five different definitions of a meal. There were no significant
qualitative differences in the results obtained with different definitions. Although data are presented from all definitions, the descriptive and inferential statistics reported in the text are for the minimum 50 kcal–45 min definition, which is presented as representative.

**Meal characteristics**

The mean amounts and macronutrient composition of the reported meals are presented in the top portion of **Figure 1** separately for meals eaten alone and with other people. Meals eaten alone contain significantly less total food energy (410 vs 591 kcal, \( t[62] = 8.39, p < 0.05 \)), carbohydrate (190 vs 241 kcal, \( t[62] = 6.73, p < 0.05 \)), fat (157 vs 230 kcal, \( t[62] = 5.88, p < 0.05 \)), and protein (65 vs 100 kcal, \( t[62] = 6.97, p < 0.05 \)) than did meals eaten with others present but are initiated with equivalent amounts of food estimated to be remaining in the stomach (47 vs 48 kcal, \( t[62] = 0.36, \text{NS} \)). Meals eaten alone had a significantly higher proportion of carbohydrate (47% vs 42%, \( t[62] = 3.25, p < 0.05 \)) and lower proportion of fat (37% vs 40%, \( t[62] = 2.91, p < 0.05 \)) than did meals eaten with other people, but the meals did not differ in their proportion of protein.

The deprivation ratios, satiety ratios, and meal frequencies are presented in the bottom portion of **Figure 1** separately for meals eaten alone and those eaten with others present. On average 1.61 meals/d were ingested alone whereas 2.12 meals/d were eaten with on average 2.83 other people present. The deprivation ratios are significantly larger (50%) for meals that are eaten with other people than for meals eaten alone (2.31 vs 3.47 kcal/min, \( t[62] = 5.51, p < 0.05 \)). The satiety ratios are significantly larger (30%) for meals that are eaten alone than for meals eaten with other people present (0.97 vs 0.68 min/kcal, \( t[62] = 5.01, p < 0.05 \)). These larger deprivation ratios and smaller satiety ratios result solely from the larger meal sizes eaten with others present; the durations of the premeal interval (209 vs 239 min) and the postmeal in-
interval (226 vs 219 min) do not differ significantly. Therefore, when other people are present, larger meals are eaten even though an equivalent amount of time has passed since the last meal and an equivalent amount of food energy is present in the stomach. It may be, then, that these meals eaten socially represent a larger response to deprivation than meals eaten alone. Additionally, when the meal is eaten with other people present, the amount of time that will transpire before another meal is initiated is not significantly different from the interval after the smaller meal eaten alone. This suggests the possibility that meals eaten socially provide less satiety than meals eaten alone.

Univariate correlations

The correlations between the preprandial factors of self-rated hunger, estimated premeal stomach content, and the duration of the premeal interval with the amount eaten in the meal are presented in Figure 2 separately for meals eaten alone and for those eaten with others present. Also presented are the correlations between the self-rated degree of hunger and the preprandial factors of the estimated proportion of the premeal stomach content composed of protein, the estimated premeal stomach content of food energy, and the premeal interval. Clearly, the presence of people during food ingestion does not affect the magnitude of these correlations. Meal size and self-rated hunger appear to be affected in the same way and to the same extent by preprandial factors regardless of whether the individual was alone or with other people. It would appear, then, that regardless of whether the meal is eaten with others present or not, preprandial factors have equivalent influences on the amount eaten in the meal and on self-rated hunger.

The correlations between the duration of the postmeal interval and the meal size and also the estimated content of the stomach at the end of the meal are presented in Figure 3 (left) separately for meals eaten alone and those...
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![Graph showing the relationship between different variables and beta coefficients.](image-url)
The correlations between the number of people present at the time of meal presentation and the meal-pattern variables are presented in Figure 3 (right). The number of people present does not appear to be associated with subjective hunger, stomach contents, or postmeal interval. It is, however, clearly correlated positively with the amount eaten in the meal. The correlations between the number of people present and the meal size, calculated for only those meals where at least one other person was present, (mean r = 0.300) are not significantly different from the correlations for all meals (mean r = 0.418). Hence, with meals eaten alone excluded, strong correlations are still produced indicating that the relationship is not simply indexing an alone–with people distinction. Note that the number of people present has the largest magnitude univariate correlations with meal size of any variable looked at (mean r = 0.418, accounting for 17.5% of the variance). This was larger than the correlations with the individual’s subjective state of hunger (mean r = 0.289, accounting for 8.4% of the variance), the premeal interval (mean r = 0.242, accounting for 5.9% of the variance), and the estimated premeal stomach content (mean r = −0.117, accounting for 1.4% of the variance) (Fig 2). It appears that not only the presence of other people but the number of people present is associated with the amount of food ingested in a meal independent of other factors.

Multiple linear regressions

The multiple-regression results indicate that the presence of other people influences the amount eaten in the meal independently of the effects of other significant influences on meal size. They further indicate that the postmeal interval is not directly affected by other people being present but that the regulation of the postmeal interval by other factors is disrupted when others are present at the meal.

The mean β coefficients from the multiple linear regressions predicting meal size on the basis of the estimated proportion of protein and the total calories in the stomach at meal onset and the premeal interval are presented in Figure 4 (top) separately for meals eaten alone and with others present (see ref 13 for the rationale for the choice of these factors). There were no significant differences between the β coefficients produced by the multiple regressions with meals alone and those with other people. Figure 4 contains the mean intercepts from the multiple-regression equations. The difference in mean sizes between meals alone and with others is completely accounted for by the difference in the intercepts (t(62) = 2.16, p < 0.05). This suggests, as did the univariate data, that the presence of other people is associated with the amount ingested in a meal independently of other regulatory factors.

The notion that the presence of others is independently associated with the amount ingested is supported by the results of multiple regressions performed across all meals reported with or without the number of people present included in the regressions. The mean β coefficients from these regressions are presented in Figure 4 (bottom). The addition of the number of people present to the regressions did not significantly alter the influence of any other factor and increased the multiple correlation from 0.54 to 0.77, more than doubling the variance accounted for (from 29% to 59%, t(62) = 5.17, p < 0.05). The number of people present, then, appears to be a major factor associated with the amount eaten in a meal and to be independent of other factors affecting meal size.

The postprandial multiple-regression results, in contrast to the meal-size regressions, appear to be somewhat different for meals eaten alone than for those eaten with others. The multiple-linear-regression predictions of the postmeal interval based upon the estimated contents of the stomach at the end of the meal are presented in Figure 5 (top) separately for meals eaten alone and with other people present. There are significant and positive associations between the estimated stomach contents and the postmeal interval for meals eaten alone but not for meals eaten with people except for the proportion of fat estimated to be present at the end of the meal. These multivariate results are similar to the univariate results reported above and may reflect a different form of regulation occurring when meals are eaten alone than when they are eaten with others present.

When the number of people present was added to the regression, it did not have a large impact. The β coefficients, (Fig 5, bottom) for number of people present are

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**FIG 4.** Beta coefficients from the multiple-linear-regression prediction of meal size (X ± SEM). Top: β coefficients for the predicted proportion of the stomach content just before initiation of the meal of protein (left set of bars), the estimated premeal stomach energy content (middle set), and the premeal interval (right set) and the intercepts of the multiple-regression equations (far right). Bottom: β coefficients from the multiple-linear-regression prediction of meal size based on the number of people present (left), the estimated proportion of the stomach content just before the initiation of the meal of protein (middle left), the estimated stomach energy content (middle right), and the premeal interval (right). The first bar of each set of five represents 15 min–50 kcal; the second, 45 min–50 kcal; the third, 45 min–100 kcal; the fourth, 45 min–200 kcal; and the fifth, 90 min–50 kcal. *Value significantly (p < 0.05) different from zero as assessed by a t test.
generally small, negative, and nonsignificant. The $\beta$ coefficients for the macronutrient proportions and the total food energy estimated to be present at the end of the meal are generally positive and significant and are virtually identical regardless of whether the number of people was included in the regression. Adding the number of people to the equation increases the multiple correlation from 0.50 to 0.65, reflecting about a 19% increase in the variance accounted for by the additional factor. In addition, the intercepts for the two sets of equations do not differ significantly. The number of people present, then, does not appear to be a major independent factor associated with the postmeal interval but rather is a significant determinant of whether postprandial regulation will occur.

**Discussion**

The present findings result from correlative evidence obtained from self-reports. The problems that are associated with this kind of procedure were discussed previously in detail (16, 17, 23) and thus will not be addressed again here. However, although correlation does not mean causation, it is a prerequisite for causation. Any causal factor should be correlated with the factor it influences. Thus, correlation can be used to test and potentially reject or support causal statements. In this study the association between the presence of people and food intake was strictly correlative and no conclusive causal statements can or should be made. It is, however, perfectly legitimate to postulate and discuss a causal linkage because the correlative evidence supports such interpretations.

The results clearly demonstrate an association between the presence of other people and the amount of food energy ingested in a meal. Meal sizes are substantially (44%) larger, including larger amounts of all three macronutrients, when other people are present than when meals are eaten alone. These larger meals occur after equivalent premeal intervals and with an equivalent amount of food energy estimated to be remaining in the stomach at the time of meal initiation. As a result meals eaten with others present have substantially larger (50%) deprivation ratios. This suggests that the amount ingested with other people present is larger than can be accounted for on the basis of prior deprivation. The satiety ratios for meals ingested with other people present are 30% lower than when meals are eaten alone, suggesting that the food does not produce equivalent satiation when eaten with others. The presence of other people, then, is associated with enlarged meals that are overresponsive to the degree of deprivation and produce decreased satiety.

This association of the amount ingested in meals with the number of people present is strong and continues to be strong even when the correlations are calculated only for meals where at least one other person is present. The relationship then is not simply forced by intermixing small meals eaten alone with large meals eaten with others present but actually represents an association with the number of people present.

The correlations between preprandial factors and the amount eaten or the self-rated hunger were not significantly different for meals eaten alone than for meals eaten with other people, suggesting that these factors continue to have equivalent effects on hunger and amount ingested regardless of the presence of other people. The multiple-regression analyses also demonstrated equivalent effects of preprandial factors on meal size regardless of the presence of other people. Hence the association of the presence of other people with enlarged meal sizes does not appear to be due to a facilitated impact of prior stomach content or time since the last meal on the amount ingested but rather appears to be associated independently of these preprandial factors.

This independence is further evidenced by the multiple-regression predictions of meal size. When the regressions were performed separately for meals eaten alone and for meals eaten with others, only the intercepts of the regression equations differed significantly. When the number of people present was added as a factor in the multiple regressions predicting meal size, the influence of the other factors was not affected but the amount of variance accounted for was more than doubled. When the number of people present was directly correlated with the meal pattern variables, only the meal size was correlated significantly. All of this strongly suggests that the presence of other people is associated with a substantial increase in the amount ingested that cannot be accounted for by the premeal state of the individual.

Do these findings suggest that the presence of other people causes an increase in intake (social facilitation) (2, 3) or that large meals are the ones that just happen to be scheduled with other people, or is some other factor responsible for the covariation? Although the present findings cannot provide a conclusive answer, they suggest that there is social facilitation (2, 3), the presence of other people causing an increase in meal size. If large meals were simply those scheduled with others, they

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**FIG 5.** Beta coefficients from the multiple-linear-regression prediction of the postmeal interval. Top: $\beta$ coefficients for the estimated proportion of the stomach content just before the initiation of the meal of carbohydrate (left set of bars), fat (middle left), and protein (middle right) and the estimated stomach energy content (right). Bottom: $\beta$ coefficients from the multiple-linear-regression prediction of the postmeal interval based on the number of people present (left); the estimated proportion of the stomach content just before initiation of the meal of carbohydrate (middle left), fat (middle), and protein (middle right); and the estimated stomach energy content (right). The first bar of each set of five represents 15 min–50 kcal; the second, 45 min–50 kcal; the third, 45 min–100 kcal; the fourth, 45 min–200 kcal; and the fifth, 90 min–50 kcal. *Value significantly ($p < 0.05$) different from zero as assessed by a t test.
would still be expected to have normal deprivation ratios, to be ingested after a particularly long premeal interval, or to be ingested with a particularly empty stomach. The fact that none of these conditions were found argues against such a scheduling interpretation. The multiple regressions suggest that the premeal factors predict a smaller meal. Only the presence of others accounts for the increase.

It could be that large meals tend to have lower deprivation ratios and also tend to be eaten with others present. This appears to be unlikely because most of the reported effects were still present when the 200-kcal-minimum meal-size definition was used and the average meal sizes for meals alone and with people were not significantly different (Fig 1). Additionally, the magnitude of the relationships between the number of people present and the meal size argues against a third factor being responsible for the covariation. The number of people present produced the largest correlation with meal size of any factor. When the number of people present was added to the multiple-regression prediction of meal size, it more than doubled the amount of variance that could be accounted for. If a third factor were responsible and it affected meal size via an intermediary, the number of people present, then only a weak relationship would be expected.

It could be argued that meals eaten alone tend to be snacks whereas main meals are eaten with others. The fact that meals eaten alone are proportionately higher in carbohydrate supports this hypothesis. However, the influence of number of people present on meal size was still present even when small meals were excluded as with the 200-kcal-minimum meal-size definition. Additionally, the relationship between meal size and the number of people present was still strong even when meals eaten alone were removed. Meal size was associated with the number of people present and not just with their presence or absence. This suggests that the influence of social factors transcends the alone–with people distinction and that there is a causal connection between the variables.

Each of the above arguments by itself is not conclusive or even compelling, but the total of all the arguments suggests and supports a causal interpretation of a social facilitation. There are a number of possible mechanisms for the increase in eating in the presence of other people. It is possible that other people increase arousal and thereby increase intake (3), that they disinhibit restraints on eating (24), or that they even may increase competitiveness for available foods. Unfortunately, the present results do not address these hypotheses, they only demonstrate the phenomenon.

A different picture emerges from the predictions of the postmeal intervals. There is no significant direct correlation between the number of people present and either the premeal or postmeal intervals. In the multiple regressions the number of people present had generally small β coefficients and did not add greatly to the amount of variance accounted for. Additionally, there were no significant differences between the postmeal intervals of meals eaten alone or with other people present. Thus it appears that the presence of other people during the meal does not directly influence the postmeal interval. Intuitively this makes sense because the postmeal interval is determined by initiation of the next meal, when other people may no longer be present.

Although the presence of other people does not appear to directly effect the postmeal interval, it does appear to markedly affect the postprandial regulatory process. The correlations between the amount eaten in the meal and the postmeal interval were significant for meals eaten alone but not for meals eaten with others present. The multiple regressions predicting the postmeal interval based on the composition of the premeal stomach contents again were significant for meals eaten alone but generally not for those eaten with other people present. This suggests that postprandial regulation is disrupted by the presence of other people.

How this could happen is not completely clear. It seems that meals eaten with other people are determined by external schedules more frequently than those eaten alone. The results, however, do not support this notion. The subjects rated fewer of the meals eaten with others as constrained than meals eaten alone. Another possible explanation is that the presence of other people at the meal disrupts the postmeal satiety process. The satiety ratios are smaller for meals eaten with other people than for meals eaten alone. It is unclear how eating a meal with other people could disrupt the regulation of the initiation of the next meal when the others are no longer present. Alternatively, the presence of other people could add another control process that obviates the need for the regulation of the postmeal interval. Regardless, the presence of other people is a disruptive influence on the processes that regulate food intake in their absence.

Because previous studies did not show postprandial relationships, multiple-regression analysis of the factors controlling the postprandial interval were not reported previously. The results clearly show (Fig 5) that the most significant factors in the postmeal interval prediction are the proportions of the three macronutrients. In the meal-size prediction, the proportion of protein is the predominant macronutrient (13). This is not the case with the postmeal interval prediction where all three macronutrient percentages have relatively large, positive, and significant β coefficients, which suggests that a high proportion of any one of them is associated with longer postmeal intervals than can be accounted for by the caloric content of the food. This suggests that imbalance in the macronutrient composition of the meal in any direction is more satiating than a balanced meal. This interesting idea needs further investigation.

Our results suggest an explanation for the difference between rat and human meal patterns. Rats have been reported to show postprandial regulation whereas humans do not. The present results support the hypothesis that humans do not normally show postprandial regulation because of disruption of this process by the presence of other people. Meal patterns for humans eating alone are postprandial like those of rats. This further suggests...
the hypothesis for future investigation that if rats were monitored under social conditions, postprandial regulation would vanish. Supporting such a view is the fact that the sizes of meals eaten by rats and other animals in social conditions are markedly larger than those eaten alone (2, 3, 25).

Our results also have implications for dietary schemes. In a sense eating alone may be viewed as healthier eating. Meals eaten alone are lower in calories and contain proportionately less fat than meals eaten with other people. Yet these meals have lower deprivation ratios and higher satiety ratios under conditions of equivalent subjective hunger and stomach content. This suggests that if people were encouraged to eat alone, they would eat less and include a smaller proportion of fat yet obtain a greater amount of satiety per calorie of energy ingested. In addition, eating alone produces clearer postprandial regulation. Hence, these results not only suggest that eating alone would reduce caloric intake but would also improve the composition of the diet and produce greater physiological regulation of intake. It remains to be seen if these predictions are accurate.

We express appreciation and acknowledge the substantial contributions of Dixie K Elmore and Margaret Pedersen, without whose assistance the work could not have been performed.

References