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Determinants of Food Intake in Obesity

Abstract. *Obese human subjects who were offered three sandwiches ate more than normal subjects. When only one sandwich was offered and additional sandwiches were available but out of sight, the obese subjects ate less than normal subjects. This result is discussed in terms of the types of cues that motivate eating for obese versus normal individuals.*

Recent work by Schachter (*1*) and his colleagues has demonstrated that the factors that govern an individual's eating behavior are related to his weight, that is, weight controlling for height. This work may be summarized by two generalizations: (i) The more an individual weighs, the less responsive he is to internal physiological cues indicative of nutritional state, and (ii) the more an individual weighs, the more responsive he is to external food- or environment-related cues.

Evidence in support of the first proposition includes a study by Stunkard and Koch (*1a*) in which a strong correspondence between extent of gastric motility and verbal reports of hunger was found for normal subjects and a much weaker correspondence for obese subjects. Schachter *et al.* (*2*) found that obese subjects ate no more food after being deprived for several hours than they did after being recently fed, while normal subjects ate much more food after they had been deprived. Goldman *et al.* (*3*) observed that obese individuals were less discomfited by enforced deprivation and altered eating schedules than normal individuals were.

The second proposition is supported by the finding of Schachter and Gross (*4*) that obese subjects ate more when they were persuaded by a speeded-up clock to believe that it was dinnertime, but this was not true for normal subjects. Nisbett (*5*) reported that overweight subjects ate far more good-tasting ice cream than ice cream adulterated with quinine, while normal subjects were less affected by the difference in taste; underweight subjects were still less affected.

If it is true that overweight individuals respond to external rather than to internal cues, it should be possible to control the amount of food they eat by varying the number of external cues that encourage eating. The most direct way to manipulate the number of external cues is simply to vary the amount of food presented to subjects. Consider the behavior we would expect of an individual who is deprived and then offered a small meal. If he is not obese, his sensitivity to internal state will motivate him to obtain more food. If it is available, he will eat more than the small amount he was offered. If he is obese, his lack of sensitivity to internal state will leave him without further motivation to eat, once he has finished the small meal. He will have eaten up all his cues, so to speak. Consider, on the other hand, the behavior we expect of an individual offered a very large meal. If he is not obese, he should leave some of it uneaten. If he is obese, he would be expected to eat most or all of the meal—in essence, he should eat until the cues are gone.

Subjects were invited to participate in an experiment involving the measurement of certain physiological variables. They were told that in order to obtain accurate base lines, it was essential that they not eat after 9:00 a.m. on the day of participation. Appointments were made for early afternoon hours so that the minimum period of deprivation was 4 hours.

The experiment was run in conjunction with one of my unpublished studies that was not concerned with eating behavior. For the purposes of that study, bogus recording electrodes were attached to the subject and he performed a "monitoring" task for approximately 30 minutes. At the end of this period the experimenter announced that the experiment was over, disengaged the subject from his electrodes, and led him into another room "to fill out some final questionnaires."

Table 1. The number of sandwiches eaten as a function of the number offered and of weight. Numerals in parentheses are numbers of subjects; MS, mean square; F, Fisher statistic.

Weight of subject	No. of sandwiches eaten when offered	
	One	Three
Underweight	1.50(10)	1.62(10)
Normal	1.96(16)	1.88(12)
Overweight	1.48(9)	2.32(12)

Analysis of variance

Source	df	MS	F
Weight (W)	2	.90	3.48*
Number offered (N)	1	1.42	5.46*
W × N	2	1.29	4.97†
Error	63	.26	

* $P < .05$. † $P = .01$.

The new experimental room contained a refrigerator, a chair, and a table on which were a bottle of soda and either one roast beef sandwich or three roast beef sandwiches. Sandwiches were wrapped in white paper. While the subject sat down, the experimenter said casually: "Since you skipped lunch for the experiment, we'd like to give you lunch now. You can fill out the questionnaires while you eat. There are dozens more sandwiches in the refrigerator, by the way. Have as many as you want." The experimenter asked the subject to check by his office on the way out, and then left, shutting the door behind him.

Several aspects of the procedure were designed to reduce possible self-consciousness on the part of overweight subjects: (i) The experimenter was absent while the subject ate, and the meal was completely private. The subject could assume that he would not be interrupted because he was to go to the experimenter's office when he was through. (ii) The subject was told that there were dozens of sandwiches in the refrigerator and could assume that if he were to take a sandwich or two it would not be missed. (iii) The subject was given no reason to assume that the experimenter had the remotest interest in how many sandwiches he ate.

Male students, in Columbia University's summer school, 25 years old or younger, whose height and weight reports indicated that they were distinctly underweight, overweight, or of normal weight, were asked to participate in the experiment. The norms published by the Metropolitan Life Insurance Com-

pany (*6*) were used to establish percent weight deviation. The distribution of subjects' weight deviations was examined for those cutoff points that permitted a 5 percent weight differential between underweight and normal subjects and between normal and overweight subjects, and at the same time involved the minimum lost of subjects. The resulting range of weight deviations were −20 to −7 percent for underweight, −01 to +09 percent for normal, and +15 to +48 percent for overweight subjects.

This experiment, then, allows underweight, normal, and overweight subjects access to as much food as they care to eat. The only difference between experimental conditions is the number of sandwiches on the table in front of the subject. Overweight subjects responded powerfully to this difference (see Table 1). Those who were confronted with three sandwiches ate 57 percent more than those confronted with only one sandwich. In contrast, normal and underweight subjects were completely unaffected by the difference between experimental conditions—both groups ate as many sandwiches when they were initially offered one as when offered three.

A comparison of the absolute number of sandwiches eaten by the three weight groups in the two experimental conditions is striking. Overweight subjects ate markedly more than either normal or underweight subjects when they were confronted with three sandwiches (P for both groups, $<.05$). But when one sandwich was presented they ate as few as underweight subjects did and actually less than normal subjects ($P < .05$).

These findings suggest that the obese individual will habitually eat everything he is served in a typical meal. His susceptibility to external cues should compel him to clean his plate. Nonobese individuals, on the other hand, who eat primarily to reduce the discomfort of hunger, should frequently leave part of their meals uneaten.

In order to assess this implication subjects were asked, on the questionnaire after the experiment, "Are you a 'clean-your-plate' type or are you likely to leave something?" Alternatives were: "I nearly always clean my plate"; "I sometimes clean my plate and sometimes leave something"; or "I nearly always leave something." The same question was asked of a large sample of Yale undergraduates. Responses of the three weight groups were similar at the two schools and these responses are pooled in Table 2.

Table 2. Responses to the "clean-your-plate" question as a function of weight. *N*, number of subjects.

Weight of subject	*N*	Responses (%)		
		Nearly always clean my plate	Sometimes clean, sometimes leave	Nearly always leave something
Underweight	82	26.8	50.0	23.2
Normal	83	39.8	45.8	14.5
Overweight	95	53.7	36.8	9.5

The probability that an individual will habitually clean his plate is highly dependent on his weight. The χ^2 based on Table 2 is 15.11, which for df = 4 is significant at the .005 level.

One aspect of the present experiment requires further discussion. It may have occurred to the reader that subjects offered one sandwich have a great many additional food cues. A refrigerator, filled with sandwiches, is across the room from them. Why then do overweight subjects not eat as many sandwiches when offered one as when offered three? (i) They may fail to do so because of the effort required to obtain food. Overweight subjects may simply have been unwilling to expend the necessary energy to cross the floor and get more sandwiches. It must be admitted that this explanation has an implausible ring, since the necessary effort was so slight. (ii) They may fail to do so because the additional food cues are not very salient or potent. Sandwiches on the table immediately in front of the subjects may compel eating; unseen sandwiches in a refrigerator may not. This alternative seems more plausible, especially in light of the present characterization of the obese. Strong, immediate food stimuli should be hard for the "external" individual to resist. Weaker, more distant stimuli may go unnoticed by the individual lacking internal motivation to seek out food.

Research on rats made obese by ventromedial hypothalamic lesions provides evidence that may be relevant to the results and interpretation of my study. In particular, an experiment by Miller *et al.* (*7*) on rats with these lesions parallels the present one to a remarkable degree. Their rats with lesions ate more palatable food that was freely available than control rats did, but when they were required to press a lever, run down an alley, or lift the heavy cover of a food cup to obtain their food, they ate less than the controls. These findings can be taken to mean that the hyperphagic rat is not only insensitive to satiety cues, since under normal circumstances it will overeat and grow fat, but insensitive to deprivation cues, since it appears to be unmotivated when there are obstacles to eating. This double insensitivity is, of course, precisely the characterization of obese humans that has been proposed by Schachter and his colleagues.

The experiment of Miller *et al.* is, moreover, open to the same interpretive possibilities as this study. Their animals with lesions may have eaten less in the "effortful" conditions because of the effort required to obtain food, or they may have eaten less in those conditions because the food stimuli were less potent. The various techniques they used to make the food more difficult to obtain would also have served to increase the distance from the food or otherwise reduce the potency of food cues.

The analogy between the hypothalamic obese rat and obese humans should be further explored, for other research has indicated parallels. Both the obese human (*5*, *8*) and the hypothalamic obese rat (*7*, *9*), for example, have been shown to be hyperresponsive to the taste properties of food.

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References and Notes

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