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Predictors of Human Food Consumption

Abstract. *Efficient psychological and nutritional measures by which food acceptance can be predicted were sought. Three-fourths of the variation in percentage of enlisted military personnel who take the foods at the serving table is predictable from knowledge of food preferences, the subjective satiety or "fillingness" of the food, and the amount of two major nutrients, fat and protein, the food contains.*

Surveys of the food preferences, as measured by a like-dislike rating scale, of the American soldier and various studies of his food acceptance behavior have shown that preference can account for 30 to 50 percent of the variability in consumption (*1*, chapter 6). Other literature, including a recent review (*2*), would lead one to expect that many variables might be needed to increase the precision with which consumption can be predicted. Our problem was to discover variables other than preference that are related to the food acceptance behavior of groups. For convenience, the variables can be grouped into three broad categories covering sensory, physiological, and attitudinal or environmental factors (*3*).

Preference is possibly a resultant of all three factors. One physiological factor, related to the amount of food ingested and to the rate of digestion, is reflected in subjective feelings of satiety. Another physiological factor is the nutritive content of the food itself, particularly the major nutrients, protein, fat, carbohydrate. Attitudinal or environmental variables would include familiarity with the food, particularly whether or not a person had ever tried it, and such factors as quality of preparation or desired frequency of serving.

All psychological or attitudinal data consisted of responses of enlisted military personnel to food names on rating scales in a questionnaire. Four dimensions were measured in each questionnaire: preference, desired frequency of serving, satiety or "fillingness," and quality of preparation. The latter three scales were similar to the various rating scales described previously (*1*). Each scale had seven to ten categories with each category anchored by a descriptive phrase. In actual use a given scale appeared nine times on a page—once for each food name. A questionnaire consisted of eight pages of rating scales plus four pages of instructions. The instructions for a given dimension of rating always included two examples. The sequence was: instructions, two pages or 18 food names to be rated, instructions on the second dimension, two pages of ratings, and so forth. There were 72 foods, 18 to be rated on each dimension for any given respondent, and there were four forms of the questionnaire so that all foods were rated on each dimension by one-fourth of the respondents.

The respondents were 400 airmen at Truax Air Force Base, Wisconsin. Most of them were technicians or technician trainees. Their activities varied and were not modified for this study. The same master menu is used for both the Army and Air Force, and on each day essentially the same meals are served in all mess halls throughout the country. The four forms of the questionnaire were interleaved so that they were assigned randomly to the respondents within any session. The number of respondents (N) for each mean rating was about 100; the variation was caused by the "not tried" responses, which naturally are higher for some foods than for others. One other predictor was included. It was the average food preference ratings obtained in a series of national surveys in the Army (*1*). These were based on an average N of 2000 and hence have greater reliability than the preference ratings from the airmen.

The food composition data were obtained from analyses of foods taken from Army mess hall serving lines (*4*), so they give the best available estimates of the composition of the foods eaten in the Army and Air Force. The data on percentage of protein, fat, carbohydrate, and water were used as such, and the first three were also converted to percentage of calories provided by each of these nutrients. This calculation, in effect, removes the water from foods—that is, it gives the composition on a dry-weight basis. A seventh measure was the calories per unit weight of food as served, termed the caloric density.

The criterion was the percentage of men taking a food from Army mess hall serving lines. In a recent study (*5*) on consumption and reasons for nonconsumption, information was obtained on about 160 different foods from the fresh garrison ration served in Army mess halls. One of the findings was that the percentage of a food eaten by those taking it was not a differentiating index of acceptance. This result arose in part because men usually ate what they took; hence, this measure showed little variability. However, the number of men taking a food from the serving line was a very discriminating measure. Since men usually ate what they took, the percentage taking a food from the serving line was considered the most meaningful measure of consumption or acceptance.

The number of messes in which a food was surveyed varied from 5 to 60, depending on the number of times a food was served during the month-long survey at four posts. The actual number of men sampled on each food ranged from a minimum of 122 to more than 2000, but for most of the foods there were 200 to 400 respondents. The study was conducted at four posts that were widely separated within the continental United States: yet, the average intraclass correlation over 66 foods that were served in more than one mess at each of the four posts was .95—a 90 percent reliability. The percentage of men taking a food ranged from 100 percent (for some meats) to less than 40 percent (for some vegetables), giving a wide range of variability.

For the attitudinal data, successive integers were assigned to the successive scale categories (see *1*, chapter 4); the integers associated with the ratings were then averaged to obtain a mean rating for each food on each psychological dimension. In addition, the percentage of soldiers circling the "not tried" category on the preference scale was calculated for each food. The data that were

Table 1. Changes in distribution of percentage of variability accounted for as a function of the number and nature of the predictors of consumption, without regard to food classes.

Predictor	Percentage of variance explained by						
	Individual predictors	Predictors in different combinations*					
Satiety	50	34		43	30	35	32
Preference	31		24	23	22	22	23
Percentage fat	31					17	12
Percentage protein	26						8
Log caloric density	43	24	37		21		
Total		58	61	66	73	74	75

* $\beta_{01.2\ldots k}r_{01}$; $\beta_{02.1\ldots k}r_{02}$, and so forth, where the β's in the products (which are the percentage variances) in different columns are from separate regression equations.

expressed in percentages (for example, for fat, or for men taking a food) were converted to anglits to stabilize the variance. The data were then subjected to multiple linear regression analyses. The results are expressed as the percentage of variability accounted for, that is, R^2.

The R^2, for all predictor variables, is 0.77. However, because some of the variables are highly related to one another, some could be eliminated by a search for the minimum number of them that could explain most of the 77 percent of the variability. It was found that 75 percent could be accounted for by four variables: satiety, preference [from the national surveys, (*1*)], percentage fat, and percentage protein. Of these, satiety and preference are the most important in terms of their contribution to the prediction of consumption. They explain about 55 percent (Table 1, last column: 32 + 23 percent) of the variability when in combination with the fat and protein values. When preference and satiety are taken alone as the only predictors, they account for 66 percent of the variation. The results for various combinations of the most important predictors are shown in Table 1.

Conversion of fat and protein content to percentage of total calories reduced their predictive abilities. This reduction is due to the fact that the conversion indirectly eliminates the role of water content; but percentage water, which has appreciable predictive power (29 percent; $r = -.54$), is, of course, inversely related to caloric density ($r = -.95$). Thus, protein and fat amounts per se are more important than their interrelationships with each other and with carbohydrate. Not surprisingly, the logarithm of caloric density may be substituted for amount of fat with almost equal effectiveness as a predictor.

If one is looking only for predictors, protein could be omitted since it raises the predictive value by only 1 percent (see the last two columns of Table 1). In fact, if empirical prediction were the problem, knowledge of the food classes alone is almost sufficient. The foods were divided into six classes: main dishes, starches, vegetables, salads, fruits and desserts, and breakfast items; then, knowing merely the class in which a food lies enables one to predict about 60 percent of the variation in percentage taking among all foods. A regression with adjustment for class differences (*6*), employing the four most important variables and the six food classes, yields an unbiased R^2 of 0.82. However, these classes in themselves are reflections of more basic characteristics of the foods; hence they shed no light on the psychological and physiological or nutritional factors that regulate food acceptance in man.

Although many factors in eating behavior have been postulated or demonstrated, relatively few variables appear to guide normal adult human eating. Each of the four variables (last column, Table 1) contributes appreciably to the explained variance, and all appear to be basic factors (*7*).

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Arousal Effects on Evoked Activity in a "Nonsensory" System

Abstract. *Responses from motor cortex evoked by cerebellar stimulation have been recorded with chronically implanted electrodes from cats in different states of arousal. The response, which in the waking cat consists of a short latency biphasic component followed by one or more slower waves, was attenuated, or abolished completely, in association with electroencephalographic and behavioral signs of decreased arousal. In contrast, responses in primary somatosensory cortex evoked by stimulating the bulbar trigeminal nucleus were enhanced during periods of decreased alertness.*

During the last several years, evidence for a concept of "central control of afferent activity" has been derived from experiments in which the configuration of evoked responses in sensory systems has been shown to be modifiable by various experimental interventions (*1*). These maneuvers have included: direct and indirect stimulation of the brainstem and thalamic reticular activating system; repeated presentation of stimuli to produce "habituation"; and association of positive and negative reinforcement with sensory stimuli.

There is no reason a priori to assume that similar plastic effects might not be demonstrable in "nonsensory" or "central-central" systems, that is, systems which are relatively remote from peripheral inflow to (or outflow from) the central nervous system and which are not ordinarily considered part of the classical sensory or "peripheral-central" input pathways. Indeed, some investigations already support this possibility (*2*). If this is the case, "central control of afferent activity" may be only part of a more general phenomenon in which activity of various systems, "peripheral-central" and "central-central" as well, is modified as the functional state of the animal changes. With this in mind we investigated the relations between state of arousal, defined by behavioral and electroencephalographic (EEG) criteria, and the configuration of evoked activity in a nonsensory, "central-central" system. A classical sensory system was also studied for comparison.

Cats were implanted under pentobarbital anesthesia with bipolar electrodes made of two strands of No. 36 gauge stainless-steel wire twisted to-