GASTRIC RESPONSE TO FOODS

X. THE PSYCHIC SECRETION OF GASTRIC JUICE IN NORMAL MEN

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As early as 1852 it was shown by Bidder and Schmidt (1) that the mere sight of food called forth the secretion of gastric juice in the dog. It remained, however, for Pavlov (2), some forty years later, to establish more definitely the character of the so-called "appetite" or "psychic" secretion of the gastric juice. He pointed out that such a secretion was the normal initiator of gastric digestion in dogs, and might be induced by the sight, smell, taste, mastication or thought of food, or even through the stimulation of appetite by the presence of solid matter in the stomach. This was further emphasized by the fact that very appetizing foods, such as meats, induced a greater secretion in "sham feeding" experiments than milk or bread, which were not so greatly relished by the animals.

The results of experiments on man have been by no means so conclusive. Thus Carlson (3) was able to point out probable sources of error in most of the earlier investigations. This author concluded from the work of Homborg (4) and his own experiments that in spite of apparent evidence in the literature to the contrary, what Pavlov found true for animals was also true for man, namely, that gastric secretion was not induced by the chewing of indifferent substances nor by the taste or smell of chemical substances not arousing the appetite sensation.

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Accepting the view that the initiation of gastric secretion is dependent upon arousing or augmenting the appetite sensation, it becomes of immediate interest to determine whether the thought, sight, smell or taste of food exerts the greatest influence in this direction as well as to estimate the absolute importance of the appetite secretion as a factor in gastric digestion.

Carlson found that no secretion could be induced in his gastric fistula subject by the thought of food, and that the secretion produced by seeing or smelling food was relatively slight and inconstant, the significant appetite secretion being that induced by the tasting and chewing of good food. Luckhardt (5), on the contrary, employing a Rehfuss stomach tube and using as a subject a completely normal man, found under good experimental conditions that the combined sight and smell of food markedly increased the flow of gastric juice.

Pavlov believed the appetite secretion to be of very great importance in initiating gastric digestion. This is discounted by Carlson, who found in his human subject, as well as in cats and dogs, that the continuous secretion of the stomach served a similar purpose, and that elimination of the appetite secretion did not cause indigestion.

That the unpalatable condition of a food need not necessarily influence its ultimate digestion and utilization in the alimentary tracts of normal men was indicated by work carried out in the laboratory of Atwater, who found that nauseating meat, the so-called "embalmed beef" fed to soldiers in the Spanish-American war, was still well utilized. That the economy of man is well served under such circumstances must remain doubtful.

In this connection it is also necessary to consider psychic or other influences tending to inhibit the development of the appetite secretion; bearing in mind that emotional excitement may destroy the motor (6) as well as the secretory (7) activities of the stomach.

The present paper is a contribution toward determining the relative importance of the various factors involved in the appetite stimulation of gastric secretion, as well as toward estimating the influence of the appetizing or unappetizing character of a meal and of the mental attitude of the subject upon the gastric response and the ultimate digestion of food.

Following the appetite stimulation in each case, the stomach was emptied at regular intervals, using a Rehfuss stomach tube, the volume of secretion determined, its free and total acidity, pepsin and amino-acid nitrogen estimated according to procedures previously described (8).
The sight psychic secretion and the effect of smell. Experiments were carried out to determine whether the sight of food alone, or the sight and odor of food combined gave rise to the production of any gastric secretion, as well as to compare the effects on such secretion of the sight of foods prepared in an unpleasing manner.

A breakfast table was set, in a small well-lighted laboratory, with clean linen, bright chinaware, and the following foods were served in a pleasant manner and at one time: ham and eggs, oranges, shredded wheat, bread and butter, hot coffee, cream and sugar. Subjects were brought to this room after any residua had been removed and the level of continuous secretion established. The nose was kept lightly but effectively clamped throughout.

In figure 1 are charted the results obtained with a subject who was a laboratory helper, accustomed to eating lunch at the laboratory. Total volumes of secretion removed are charted with total and free acidities, amino-acid nitrogen values and a so-called total actual acidity which indicates the product of the volume by the total acidity and represents the total amount of acid in the gastric samples.

It will be noted that this subject showed a marked response to the sight of food as regards the volume of gastric juice secreted and the "total actual" acidity. The continuous secretion in this case was high and a greater augmentation by psychic stimulation might perhaps be expected. Under similar conditions another subject (fig. 2) showed a lower and less acid continued secretion. Sight augmented the volume but slightly, although the acidity was distinctly increased.

Somewhat less accustomed to eating in the laboratory were the subjects of the experiments charted in figures 3, 4 and 5, which were carried out in exactly the same way except that clamps were not used. The distinct but not voluminous secretion in these cases may be attributed mainly to the effect of sight as the odor of the meal was not pronounced and odor was found to have little influence on psychic secretion in these subjects. The subjects were, of course, led to believe they would actually receive the food.

To determine whether any elaboration in setting was requisite for the stimulation of secretion by sight, the meal was simplified to a simple half grape fruit served in the usual way. The odor being imperceptible, the noses were not clamped. The results are charted in figures 6 and 7. A stimulation of secretion was brought about by the sight of the food in both cases. It is also probable that some of the psychic secretion may leave the stomach during the intervals of the experiment with the
increase in gastric tonus and produce a stimulation of the pancreatic secretion.

The effect of allowing subjects to seat themselves at a breakfast table prepared in an unpleasing manner was also tried out on six subjects. The same table was used as in the preceding experiments, and the same foods were served. However, the ham and eggs were scorched; the shredded wheat biscuits and bread roughly broken; the coffee and milk weak and diluted; the butter soft; sugar lumpy and dark; the oranges partly squeezed; the dishes generally somewhat greasy and with an appearance of dirtiness induced by the use of charcoal. Newspapers were used in place of linen. The noses of the first two subjects were clamped, of the others free.

The results of these experiments are charted in figures 8, 9, 10, 11, 12 and 13. In only one of these cases (see fig. 12) was any secretion induced above the level of the continuous secretion. It is evident, therefore, that food served in an unpleasant manner will not give rise to an appetite secretion under ordinary conditions, although custom and degree of hunger will naturally influence the conception of an appetizing food.

Breakfasts served in a pleasant manner and with appetizing foods were set before each of the six subjects just mentioned from 15 to 30 minutes after they had been presented with a view of a breakfast of the opposite and discouraging character and which had evoked no psychic gastric response. The results are plotted in the same charts as the preceding tests (figs. 8, 9, 10, 11, 12 and 13).

It will be noted that in the first two cases a marked appetite secretion followed the presentation of the second meal, this being a sight effect as noses of these subjects were clamped. However, the other four subjects did not show a psychic secretion under these conditions. The subjects showing a response were accustomed to eating in the laboratory and may have felt that they would not be expected to actually partake of the disagreeable food. The other subjects having no knowledge of the character of the test might well be more strongly repulsed by the first meal, this effect being carried over for the period of 15 to 30 minutes until the palatable meal was set before them. A secondary effect might also be their suspicion that since they were not permitted to partake of the first meal they might not have a chance at the second, although the contrary view was impressed upon them.

The psychic secretion and the odor of food. The influence of the odor of food alone on psychic secretion was tried out on seven subjects (see
The odor of frying beefsteak was used as a stimulus, the odor being pleasant, strong and unmistakably that of an appetizing food of common consumption. Subjects were blindfolded and the ears were muffled in order to exclude the influence of the sight of the steak and of hearing it fried. Subjects inhaled liberally the fumes arising from the frying steak. As in our other tests, the subjects had had no food for fourteen hours.

Three of the subjects showed no increase in the volume of secretion under the influence of these odors. The four others showed some increase, but in no case was the secretion voluminous. It would appear from these tests that odor was considerably less important than sight in inducing the appetite secretion, at least in man. These results are supported by the experiments previously mentioned, in which combined sight and odor of food brought forth no greater secretion than sight alone. Odor may have an influence on the motor activity of the stomach and may be of importance in animals with a more highly developed sense of smell. There may very well also be considerable differences in individuals of the human species.

The psychic secretion and the tasting and chewing of food. The subjects of the preceding tests on the influence of odor were permitted to rest for half an hour to reestablish the level of continued secretion which had in most cases been little affected. They were then permitted to chew for five minutes portions of tenderloin steak with strict caution to swallow none of the pieces, this possibility being checked by careful examinations of the gastric contents. In all cases the subjects remained blindfolded. In the first four cases the noses of the subjects were also clamped so that none of the vapors could be inhaled by that channel. The results are charted in figures 14, 15, 16 and 17, and show no distinct influence of tasting and chewing meat under these conditions upon the secretion of gastric juice. In one case the volume of gastric contents was somewhat increased, but the low acidity shows that very little acid gastric juice could have been secreted. Apparently the taste and chewing of food in the absence of sight or odor produced no marked psychic secretion.

In three other cases the same procedure of chewing and tasting beefsteak was carried out, but the noses of the subjects were unclamped, sight, however, being excluded (see figs. 18, 19 and 20). As illustrated in these cases the influence of the combined tasting, chewing and smelling of food on the secretion of appetite gastric juice was very pronounced and was much greater than that of smell alone.
The influence of the sound or thought of food. Subjects were blindfolded and had their noses clamped to exclude the sight and smell of food. They were seated before a frying pan in which a steak was being broiled with plainly audible sputtering and sizzling. They were told what a fine, juicy steak was being prepared for them and a general attempt made to keep their attention on the subject of appetizing meats. The results are charted in figures 21 and 22. In one case the result was negative; in the other case a distinct stimulation of secretion resulted. The variation must be ascribed to individual differences.

After one-half to three-quarters of an hour rest, the nose clips were removed and the subjects permitted to smell as well as hear the sputtering of frying steak. Results are plotted on the same charts and show that in one case a very slight rise in secretion took place. In the other case a definite stimulation occurred, although the earlier level for hearing and thought of food was not surpassed. In one case the subject was permitted to smell feces of a repulsive odor fifteen minutes after smelling steak. Any psychic secretion appears to have been depressed to the level of the continuous secretion but not below this.

Experiment 23 gives a comparison of the psychic effects of: a, the sight of a frying steak (ears not stoppered); b, sight and smell; and c, taste of the same food. A distinct stimulation was produced by the sight of the food. One-half hour later the sight and odor of similar food produced a very similar stimulation. After a further interval of 15 minutes the taste of the food gave a lesser stimulation than sight or sight and smell had previously done.

A summary of some of the results obtained on two of our subjects in so far as volumes and "total actual acidities" of appetite secretions were concerned, is given in figures 24 and 25. They must, of course, be considered in connection with details of individual experiments. They serve, however, to emphasize the important rôle of the sight of food as a stimulus to the appetite.

The influence of palatability or unpalatability of a meal on its gastric digestion. Two subjects were given uniform meals prepared and served in the ordinary manner. On a later day they were given the same foods prepared in as unpalatable a manner as possible without altering their chemical composition. The meal used consisted of: cream of wheat, 100 gm.; sugar, 10 gm.; milk, 35 cc.; coffee, 100 cc.; graham crackers, 50 gm.; oranges, 50 gm.; water, 100 cc. On the second experimental day these foods were all mixed together in a conglomerate
mass, discolored with small amounts of burnt crackers and charcoal, and the atmosphere at the table saturated with the repulsive odors of valeric and butyric acids.

The first of these subjects was of a nervous temperament and from his statements and manner was judged to be easily influenced or disturbed by the character and preparation of his food. In fact he positively refused on one occasion to continue eating a meal of the second type mentioned above, although urged to do so in the interest of science. The results on this subject (see figs. 26 and 27) show no delay or inhibition of the acid response of the stomach, although the evacuation time was somewhat prolonged.

The second subject was accustomed to eating in a laboratory, was of a phlegmatic temperament, claiming and appearing to be very little disturbed by the appearance of food or the condition in which it was served. The results on this subject are given in figures 28 and 29. The unpalatable food showed a rapid, though not quite so rapid, development of acidity and a few minutes quicker evacuation.

The first subject was also tried out with a palatable meal 50 minutes after he had violently refused one which he believed to be contaminated. The result is charted in figure 30. The development of acidity was even more rapid than in the case where the meal was given under normal conditions. If any depression of psychic secretion was carried over through this interval, there were no signs of it.

The first subject was also given a meal of unpalatable character similar to the ones already described, but prepared by himself and hence known by him to be innocuous. The results as charted in figure 31 show a rapid development of acidity and quick evacuation.

Some information with regard to the gastric response to foods unpalatable in appearance, odor and taste was obtained by experiments on the feeding of Chinese preserved duck eggs called ‘pidan.’ These eggs have dark greenish yolks and yellow-brown ‘whites’ of a firm, gelatinous consistency and possess distinct odors of ammonia and hydrogen sulphide. One subject disliked these eggs but did not know what they were and was not especially prejudiced against them. The other subject, ‘Don,’ was of a nervous type, and just as he finished eating the eggs he was told in a joking manner by one of the laboratory wits that they were of prehistoric Chinese origin. The subject became clearly suspicious that something had been given him that was not entirely fresh. The results of this test as compared with similar tests on boiled duck eggs and on raw white and yolk of egg are given in
figure 32. They show a depression of gastric secretion after “pidan” lasting for an hour and a quarter, the acidity then rising rapidly to normal figures. This delay may have been due to inhibition of appetite secretion, gastric activity being finally aroused through chemical stimulation following the solvent action of the slow continued secretion.

The failure of this unappetizing food to arouse the secretory or motor activities of the stomach to a normal response is indicated also by our results on the first subject mentioned above. The curves are given in figure 33 and show that while raw hens’ eggs gave an acid response of over 100 in the first hour and left in 2 1/2 hours, the preserved eggs at no time gave acidities of over 30 and remained in the stomach 4 1/2 hours. It appears that the unappetizing character of these eggs led to a delayed acid response and slow evacuation, perhaps complicated by their failure to show some early digestion with consequent chemical stimulation.

Influence of prejudice against a food on its digestibility in the stomach. It is very common to find people who have a prejudice against certain foods generally classed among the most wholesome articles of diet. Certain cases may be due to a food anaphylaxis or sensitivity. Others may be due to defective gastric or intestinal digestion or other causes. Undoubtedly many have no foundation and are the results of wrongly placing the blame of certain digestive disturbances.

One of our subjects, “Ham,” had a strong prejudice against eggs in any form and had not eaten them for years. He was with difficulty persuaded to take eggs prepared in several different ways. The results of these tests are plotted in figure 34, and show that eggs were digested by this subject in a perfectly normal manner, at least as far as the stomach was concerned. Neither did untoward symptoms of any kind develop.

Influence of newspaper reading on gastric digestion. Subjects were permitted to read newspapers throughout the course of a meal of palatable foods, the same test meal as used in previous experiments. The gastric responses of two subjects who read newspapers and responses of same subjects with no reading but with usual table talk are charted in figures 26, 28, 35 and 36. No distinct influence of newspaper reading was noted. Responses were quite normal in all cases. The slight differences in acid development and evacuation time were in one case favorable and in the other case unfavorable to newspaper reading.

Influence of the unpalatable character of a diet on its ultimate utilization by the human body. Smith, Holder and Hawk found (9) in a metabolism experiment on a normal man that where a uniform diet of a
palatable character was given for several days, followed by a period in which the same foods were jumbled together in dirty dishes and served amidst ill-smelling and otherwise unpleasant surroundings, that the nitrogen utilization in the first case was 86.7 per cent and in the second, 85.0 per cent. The nitrogen balance showed a retention in the first period of 3.0 per cent and in the second, of 6.4 per cent. This in spite of the fact that the subject was only with difficulty persuaded to eat the unpalatable food and that another subject who was given the same kind of food became nauseated and could not continue.

Influence of anxiety on gastric digestion (10). The study of the influence of emotional strain on digestion in man offers some difficulties due to the fact that the emotions cannot be readily controlled, nor are the subjects of extreme emotion readily amenable to experimentation. We were, however, able to obtain an interesting illustration of the profound effect of mental anxiety on gastric digestion in the case of one of our subjects. The man was a first-year medical student who had previously served as a subject of gastric tests. He was given 100 grams of fried chicken on the morning of an important examination in chemistry and was asked to write out his answers during the course of the test. He was plainly worried over the outcome of the examination and of his year's work. The effect upon gastric digestion was the prolonging of the evacuation time to 6½ hours. The intra-gastric acidity remained in the neighborhood of 90 for 3 hours. The normal digestion curve for fried chicken on this subject was obtained a week later under the best mental conditions. The time required was 4½ hours and the maximum acidity about 65. It is not at all surprising that worry aggravates a condition of gastric ulcer.

An interesting experiment on the digestion of milk in the human stomach may be cited in this connection (11). It was found that in the stomach of one of our subjects milk would not curdle. The test was carried out at the end of the year immediately before the final examinations. The subject was one of the most brilliant students in his class and had worked hard. We made several tests on this student and in every case milk left his stomach rapidly and without curdling. He digested all other food normally. The next fall, upon his return to college, we made another milk test upon him and found that his stomach curdled milk in a normal manner. At this time he was in fine physical condition, having had a long, pleasant vacation, whereas in the spring he was in a highly nervous state as a result of his hard study. This serves to illustrate the influence which rigid and prolonged mental application may exert upon the stomach in certain types of individuals.
SUMMARY AND CONCLUSIONS

The sight alone of a table well set with nourishing foods was found to give rise to a distinct secretion of gastric juice in normal men. The sight of a half grape fruit only resulted likewise in an appetite secretion. The sight of the same foods illy prepared and poorly served resulted in no stimulation of appetite secretion. The service of a well prepared meal half an hour after the service of a poorly prepared one gave in some instances a distinct secretion, in others not.

The odor alone of frying meat produced in some cases no appetite secretion, in others a slight secretion. Odor alone produced less stimulation than sight alone.

The tasting and chewing of food in the absence of smell or sight produced no marked psychic secretion. The combined influence of the tasting, chewing and smelling of food was pronounced and much greater than that of smell alone.

The sound and thought alone of a frying steak gave rise to a gastric secretion. The influence of smell with hearing produced little additional effect. Evil odors depressed secretion to the level of the continuous secretion.

In consecutive tests the sight of food, with and without odor, produced similar degrees of stimulation, while taste alone had less effect.

Mixed meals consisting of nourishing ingredients but very unpleasantly prepared and served gave rise in the case of a phlegmatic individual to no distinct delay in the development of intra-gastric acidity or in evacuation. A more susceptible individual showed a slight delay in evacuation time, but none in acid response.

Chinese preserved eggs, unpalatable to our subjects in appearance, odor, taste and belief in their unwholesome character led to delayed acid response and evacuation. In one case the normal acid level was ultimately attained due to chemical stimulation.

In one subject a strong prejudice against eggs was found not to result in any abnormal gastric response when eggs were eaten.

The ultimate utilization of the protein of a diet prepared in a most unpalatable manner was not found to be appreciably less than that of the same diet served under the best conditions.

Newspaper reading during the course of a meal could not be shown to have any distinct influence on gastric digestion.

Anxiety and mental strain were found to markedly delay gastric digestion.

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Fig. 10.

Case, 30-Cry.

Total
Sight, fundus
Sight, grad
Rest

Fig. 11.

Case, 31-Month

Sight, fundus
Sight, grad

Fig. 12.

Case, 32-Sue

Unpalatable Meal
Palatable

Fig. 12.

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Case, 26-OBr.

FIG. 19.

Case, 27-WH.

FIG. 20.
Case, 9-Mi

Fig. 21.

Case, 11-Go

Fig. 22.

20
Case, Don-39
- Raw Yolks (Yo)
- Raw Whites (Wh)
- Hard-Boiled Turkey Eggs (Bo)
- Chinese Pidan (Pi)

Meal, unpalatable

Fig. 31.

Fig. 32.
Case 18-Go
Meal, palatable newspaper reading.

Fig. 35.

Case 20-Mi
Meal, palatable newspaper reading.

Fig. 36.