PAROTID GLAND SECRETION IN AFFECTIVE MENTAL DISORDERS.

By H. J. EYSENCK, Ph.D.,* AND P.-M. YAP, B.A.,
Psychological Laboratory, Mill Hill Emergency Hospital.

INTRODUCTION.

Parotid gland secretion is one of the most easily observable manifestations of autonomic activity, and a study of the secretion of this gland should be helpful both in the elaboration of the theory of autonomic activities and perhaps also in practical diagnosis (1, 2, 3). Strongin and Hinsie have shown that whereas normal subjects secrete on the average ·07 c.c. per 5-minute period, varying from ·02 c.c. to ·15 c.c., none of a number of manic-depressive patients studied by them secreted more than ·01 c.c. per 5-minute period (4, 5).

Although age, general food and water intake, smoking habits, etc., were not controlled, thus making the two populations not strictly comparable, these results strongly suggest that in affective disorders there is a tendency towards a less copious flow of saliva under the conditions of the experiment. The experiment to be described was designed to test this hypothesis with respect to neurotic (depressed and anxious) and psychotic patients.

Another problem which was investigated simultaneously was that of the effect of mental effort on parotid secretion. Brunacci and de Sanctis were the first to show that mental effort had an inhibitive effect on salivary secretion (6); Lashley, however, found that mental work had rather a stimulating effect (7, 8). Winsor reports results supporting Brunacci and de Sanctis (9). It appeared desirable to investigate this problem, not only because of its intrinsic interest, but primarily because it appeared possible that patients suffering from affective disorders might show not only a difference from the control group in the absolute amount of saliva secreted, but also in their reaction to mental stimuli.

THE EXPERIMENT.

Measurement of the secretion of the parotid gland was carried out in the following way: The subject was seated in a chair, reassured about the purpose of the experiment, and encouraged to assume a comfortable position. Copious secretion to facilitate the fixing in the right position of a small disc similar to that developed by Lashley (7, 8) was ensured by dropping some lemon essence on the tongue of the patient; the disc was then firmly held over the opening of Stenson's duct by suction produced by inhaling on a tube leading from the outer chamber of the disc. From the inner chamber of the disc a small rubber drainage-tube passed through the corner of the mouth of the subject, carrying the secretion to the actual measuring device, which was modified from Richter and Wada's description (10). In this device the saliva is drained off through a long, thin, horizontal glass tube, calibrated in mm., and the actual progress of the saliva is indicated by means of an air bubble, introduced through a T-connection.

The neurotic patients taking part in the experiment, all of whom were tested at Mill Hill Emergency Hospital, were divided into two groups. As the experimental group we took patients diagnosed as anxiety and/or depression cases; as the control group we took patients of varied diagnosis not showing pronounced affective symptoms, i.e. hysterics, some effort syndrome cases, etc. The respective numbers in these categories are given in Table I. Also given in that Table are the numbers of the psychotic affective and psychotic control groups, all of whom were tested at St. Francis' Hospital. The control subjects were mainly paranoid schizophrenes; the experimental group consisted of patients with endogenous depressions and melancholias, showing, however, in many cases definite reactive features. The psychotic and neurotic groups are discussed separately in later sections.

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TABLE I.

Classification.	Male.	Female.	Total.
Neurotic controls	12	12	24
Anxiety cases	13	13	26
Depression cases	13	13	26
Psychotic controls	8	5	13
Psychotic affective disorders	4	7	11
Total	50	50	100

Three separate experiments were carried out. In the first experiment the patient was allowed to settle down and to get over the effect of the lemon essence on his tongue. Then readings were started, and the amount of secretion in c.c. determined for the following periods: (1) Three minutes' silent reading; (2) three minutes' rest; (3) three minutes' mental arithmetic, the patient writing down the results; (4) three minutes' rest; (5) three minutes' food imagery, aided by the showing of coloured pictures of food, taken from American magazine advertisements; (6) three minutes' reading; (7) two minutes' work on the Triple Tester*; (8) thirty seconds' rest; (9) two minutes' work on the Triple Tester; (10) three minutes' reading; (11) three minutes' rest. Pauses during which no readings were taken were introduced after periods (5), (6), (8) and (9) in order to let the possible after-effects of the preceding period's work wear off. These pauses lasted for only about 30 seconds. In this experiment all the 76 neurotic patients took part.

In the second experiment 24 neurotic patients took part, men and women being taken at random in equal proportions from each of the neurotic groups given in Table I. This experiment began, like the first one, with (1) a three minutes' reading and (2) a three minutes' rest period, followed by (3) three minutes' mental work, and (4) three minutes' rest. (5) Next the subject with closed eyes had a bottle of banana essence held under his nose for 30 seconds, followed after (6) thirty seconds' rest by (7) a bottle of pineapple essence, and, after (8) another 30 seconds' rest, by (9) a bottle of vanilla essence. (10) 30 seconds' rest and (11) three minutes' reading concluded the experiment. The three smells were strong and easily recognizable; pineapple was the strongest, vanilla the weakest.

The third experiment was carried out on the 24 psychotic patients, and followed exactly the same course as the second experiment, except that the "food imagery" test was interpolated after the second "rest" period.

RESULTS.

The total salivary output during the eleven periods of the first experiment was determined for each subject, and the results are plotted separately for the control and the affective groups in Fig. 1. The two affective diagnoses from Table I were taken together as one group because the average secretion of the patients in these groups did not differ to any significant extent. It will be seen, however, that the affective group as a whole differs considerably from the control group; while the average amount of secretion of the affective group was only ·58 c.c., that of the control group was ·82 c.c. This difference is statistically significant. It will be seen from the figure that 55 per cent. of the affective group secreted less than ·40 c.c., while only 35 per cent. of the control group secreted less than ·40 c.c.

The question naturally arises whether this difference exists in each one of the eleven experimental periods, or whether it becomes apparent in only a few of them. Fig. 2 shows that the amount of secretion of the two groups runs a closely parallel course, with the affective group consistently secreting less than the control group. This figure gives the average output of each group for 3-minute periods; periods of less than three minutes have been multiplied by a suitable constant to make them comparable. (Thus secretion during the "Triple Tester" period was multiplied by 3/2, etc.)

* The Triple Tester, designed and produced at Cambridge University, is a modified form of the Pursuit Rotor. The subject is required to manipulate a wheel which governs a stylus travelling on a drum bearing a number of dots; the number of dots touched by the stylus during a two minutes' run is recorded automatically, and constitutes the subject's score. There are two ways of operating the machine: direct transmission, which was used in (7), and indirect transmission, which was used in (9).

Fig. 3 shows the average secretion of the whole group (controls + affectives) during the (averaged) periods of rest, of reading, etc. In other words, for the purpose of this figure the various periods of rest have been combined into one

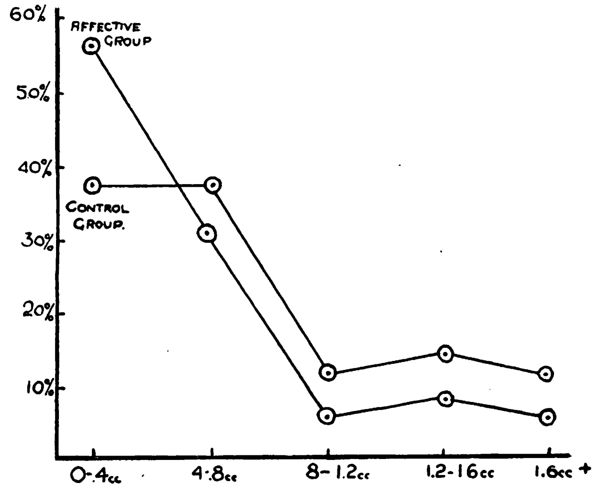

FIG. 1.—Total parotid gland secretion during experimental period of affective and control neurotic groups.

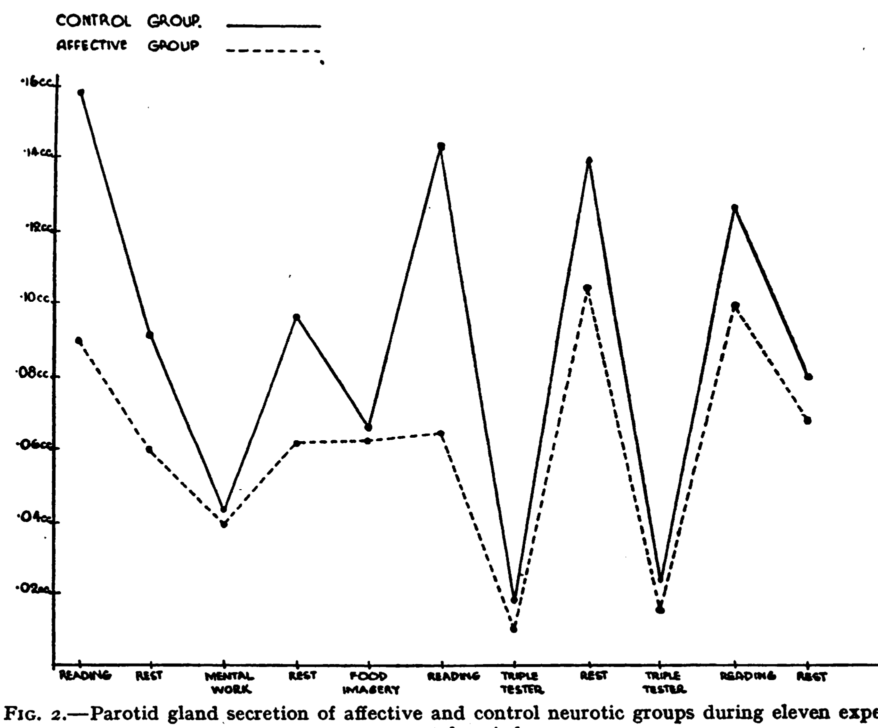

FIG. 2.—Parotid gland secretion of affective and control neurotic groups during eleven experimental periods.

score, as have the various periods of reading, etc. The figure brings out clearly that maximum secretion took place during the reading periods (·10 c.c.), and least during the " Triple Tester " periods (·01 c.c.).

Fig. 4 shows the scores of 24 neurotic subjects on the tests making up the second experiment. Again periods shorter than three minutes have been corrected to three-minute periods, in order to make the results comparable. As these 24 subjects had also taken part in the first experiment, we can derive a measure of reliability from their respective scores in the two experiments. Using total

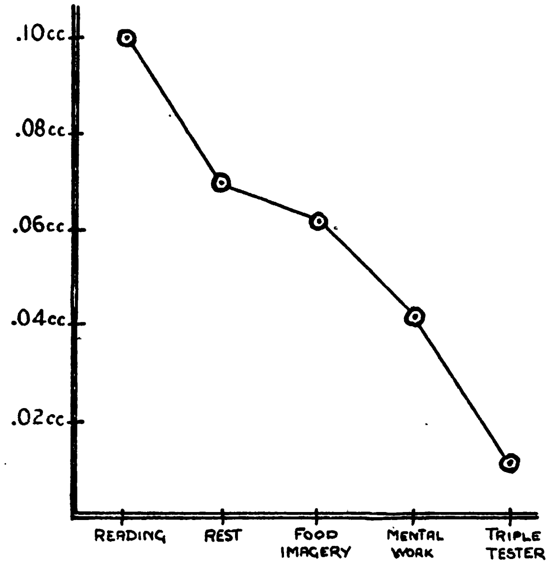

FIG. 3.—Average parotid gland secretion of total neurotic group during periods of reading, rest, etc.

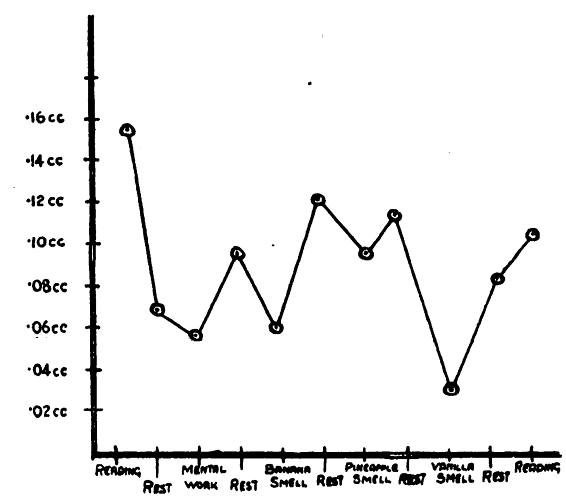

FIG. 4.—Parotid gland secretion of 24 neurotics during olfactory and other stimulation.

amount of secretion in each case, we find that the scores on the two experiments correlate to the extent of ·54 ± ·15 S.E. This correlation probably underestimates the true reliability, because different sub-tests were used in the two experiments to make up the total score. The subjects were tested at the same time of day for both experiments.

Fig. 5 shows the secretion of the affective and control psychotic groups on the 14 tests making up Experiment 3. It will be seen that apart from a slight overlap of the two curves at one point, they run a comparatively parallel course, the affective curve being consistently below the control curve. The total amount of saliva secreted during the period of the test was 1·31 c.c. on the average for the control group, and ·96 c.c. on the average for the affective group. This difference is statistically significant.*

It is interesting to note that the ratio, $\frac{\text{secretion of controls}}{\text{secretion of affectives}}$, is almost identical for the neurotics and the psychotics; for the neurotics it is 1·41, for the psychotics 1·36. Where so many variables could not be controlled, such as different food in different hospitals, different lengths of stay, different attitudes to doctors, etc., this coincidence should not be considered as anything more than a pointer for future research; it seems of sufficient interest, however, to be mentioned in passing.

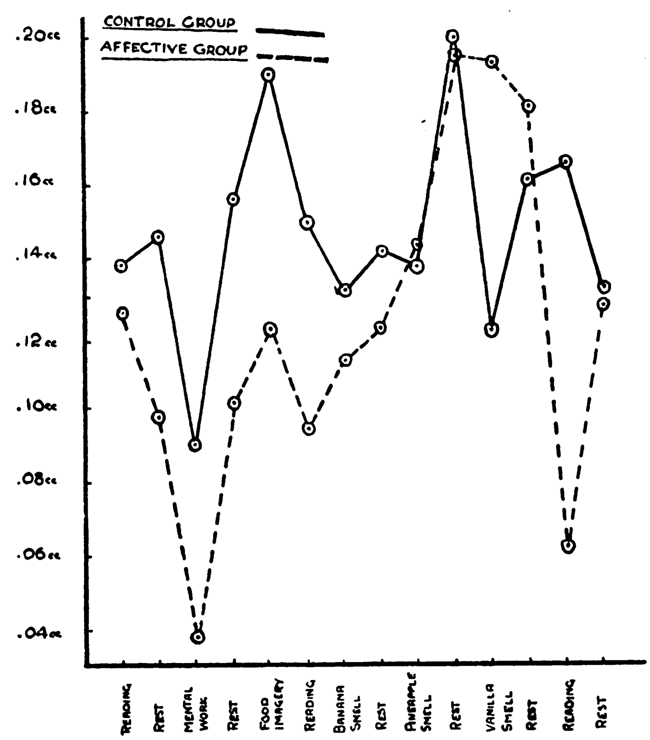

FIG. 5.—Parotid gland secretion of affective and control psychotic groups during 14 experimental periods.

When the scores of the two sexes were plotted separately, it was found that on the average the women secreted slightly less than the men, in the proportion of 1·0 to 1·2. This difference is about as large as the difference in body size between the sexes, and suggests that secretion is partly determined by general size. As long as we do not know the correlation between body size and amount of salivary secretion, this cannot be more than a suggestion; it remains possible that quite independently of body size women tend to secrete slightly less saliva than men. It is interesting to note that Wenger observed the same phenomenon in his measurement of the secretion of young children; there also girls secreted less than boys in about the same proportion as did our patients (11, 12). In this case, of course, body size cannot be responsible, young girls not being any smaller than boys.

* It will be noticed that the psychotic groups tend to secrete more saliva than the neurotic groups. This may possibly be due to the fact that the psychotics were, on the average, 25 years older than the neurotics. No reliable figures are available regarding the influence of age on salivation, but observation suggests a positive correlation.

Discussion.

The fairly definite nature of the results reported in the previous sections hides several problems to which we cannot give an answer. The fact that under the conditions of the experiment patients with affective disorders secrete less saliva than do the patients in the control groups does not prove, for instance, that in general patients with affective disorders secrete less saliva than other neurotics and psychotics. The discrepancy between the groups may be due wholly to their different reactions to the experimental situation. It is well known clinically that emotional experiences may have an inhibiting effect on salivary secretion, and to the affective patients the experimental situation may have a much more emotional meaning than to the controls (12*a*).

Again, it must remain doubtful if the secretion as measured by means of the Lashley technique actually measures normal salivary secretion, or whether it only measures the salivary secretion produced by the parotid gland under the artificial conditions of sensory stimulation induced by the Lashley disc. The arguments usually brought forward against this interpretation do not seem quite conclusive. No doubt it is true that early experimenters (13, 14, 15), who observed subjects with fistulas and found no parotid secretion when the subject was resting, erred, as Krasnogorski has pointed out, in considering that secretion from such fistulas was a reliable index of parotid activity (16); yet it is doubtful if secretion during stimulation by the Lashley disc is an altogether reliable index either.

Two reasons often given for assuming that secretion is not due to sensory stimulation are (1) that the flow of saliva decreases considerably when the subject lies down to rest, and (2) that additional mechanical stimulation in the mouth does not increase salivary flow. Against these arguments it may be urged that it is well known that there is a considerable reduction of salivary flow during sleep (17), and the semi-hypnagogic state of the resting subject might possibly account for a lessening of the effects of awareness of stimulation through the disc. As regards additional mechanical stimulation, it is only necessary to call to mind the Weber-Fechner Law to see that the experiment leaves the matter indeterminate.

Perhaps a more convincing argument could be based on the fact that in Fig. 2 there is no evidence of any decline in the amount of salivation from the first six minutes of reading and rest to the last six minutes of reading and rest, almost 30 minutes later. If the original salivation had been caused to any significant extent by awareness of mechanical stimulation, one might suppose that adaptation would have reduced the flow during the period of the experiment.

Yet while this argument may be allowed a certain cogency, it should not be forgotten that there are great individual differences in the reactions of subjects to the experiment, and that averages tend to gloss over these differences, and may be definitely misleading. The safest conclusion to be drawn from the evidence at the present moment would seem to be that the amount of salivary secretion during an experiment of the type here described may be due to three factors: (1) The natural rate of salivation of the subject; (2) awareness of the mechanical stimulation of the wall of the mouth through the Lashley disc; (3) the emotional reaction of the subject to the experiment. It is quite likely, furthermore, that these three factors assume different inportance for different subjects, and at different times for the same subject. The fact that the retest correlation is not very high supports this view.

Provided we recognize the limitations of the experimental procedure, and take care not to over-interpret our data, we may note some definite conclusions. Thus under the conditions of the experiment there is a significant difference between patients with affective disorders, both neurotic and psychotic, and patients with hysterical, schizophrenic and other non-affective disorders. Whether this difference was due to a generally less copious flow of saliva in the affective group in ordinary circumstances, or to their more emotional reaction to the experimental situation, we were not able to determine. The fact that both the affective and the control groups showed similar reactions to a variety of stimuli, such as reading, mental work, the Triple Tester, etc., might perhaps be adduced in support of the first view, but cannot be regarded as definitely proving the correctness of this view.

As regards the effect of mental work on our subjects, the results definitely support Brunacci and de Sanctis (6). Secretion is about ten times as copious during silent reading as during the continuous and strenuous mental exertion involved in working the Triple Tester. Secretion during rest is about twice as copious as during mental work (arithmetic). While we may thus regard the fact as established that under the experimental conditions mental effort decreases parotid secretion, the explanation of the fact is by no means simple.

On the view that we are measuring normal parotid flow, our data would be interpreted as showing a direct diminution of flow consequent upon mental activity; on the view that we are measuring parotid flow produced largely by awareness of mechanical stimulation, we would say that mental work directs attention away from the foreign body in the mouth, thus decreasing its stimulating effects. In favour of the first view is the fact that during reading there is a significantly more copious flow than during rest; it is difficult to account for this fact in terms of attention paid to a foreign body in the mouth. There are, however, difficulties in accounting for this fact in terms of the first view too; reading, after all, is mental work also, and should therefore produce a reduction in salivary flow from the resting state. Possibly the relation between salivation and mental stimulation is curvilinear; both low mental activity (sleep) and high mental activity (mental work) produce a reduction in salivary secretion; silent reading is mid-way between the two extremes, and shows maximum secretion. Rest is some way towards the " sleep " side of our continuum, and therefore shows a reduction in secretion as compared with reading. While this view is in accord with such experimental data as are in our possession, it cannot be regarded as anything but a theory which remains to be proved.

A curious fact which demands some explanation is the position of " Food Imagery " in Experiment 1, and of the olfactory stimuli in Experiments 2 and 3. Food imagery produced only ·06 c.c., as compared with ·07 c.c. secreted during rest; similarly, as shown in Fig. 4, and less clearly in Fig. 5, olfactory stimulation produced less salivary flow than did the intervening rest periods. This is so much at variance with our everyday experience that an explanation is required.

Two explanations are suggested by the experimental data. In the first place there are great individual differences between subjects in their reactions to olfactory stimuli; thus Winsor found in the case of one subject that " whenever olfaction alone was used . . . there was no evidence of a conditioned response " (17, p. 363). The actual data given by him show that the response during olfaction was less than during the rest periods. Thus in some individuals olfaction does not produce the usual phenomena of increased salivation. This fact is well in accordance with results obtained by M. Davies Eysenck (18), who found great individual differences in the attitudes of her subjects to olfactory stimuli, and in their sensory discrimination of them.

The second explanation is that, in Winsor's words, " when the stimulus was prolonged without reinforcing the unconditioned response, the flow soon fell to the level of the non-stimulated period. In the human subject this unconditioning process would seem to proceed much more rapidly than was the case with Pavlov's dogs " (17, p. 363). We also found that, after an initial spurt of salivation, when the olfactory stimulus was produced, salivation returned to a normal or subnormal level. The fact that this level was often subnormal may be accounted for by the fact that a certain amount of cognitive effort is involved in olfaction continued over a period of time.

It should be noted that the strongest smell (pineapple) produced ·09 c.c. of salivation, as compared with ·05 c.c. (banana) and ·03 c.c. (vanilla), the weakest. (The average secretion during the rest periods following upon these three periods of olfaction was ·10.) This suggests that the more pungent the smell, the greater the amount of salivation. It would be interesting to compare a large number of olfactory stimuli with regard to the salivary secretion associated with them, and perhaps to correlate the resulting order with the order of preference for the same smells (*cf.* (18) for a discussion of preference rankings for smells).

A point which is perhaps worth mentioning relates to Fig. 1. This figure shows clearly that the distribution of " amount of salivation " under the experimental conditions is not normal, but J-shaped. While it would of course be possible to change the shape of the distribution into a very much skewed normal curve by dividing the base-line into smaller units, yet the distribution would still be decidedly abnormal. We cannot suggest any explanation for this type of distribution, which is not usually found with biological data of this kind.

Summary and Conclusions.

The salivary secretion of altogether 100 neurotic and psychotic patients was measured in c.c. by means of the Lashley disc, under a variety of different conditions, such as olfactory stimulation, rest, reading, mental work, etc. Under these experimental conditions the following results were found:

(1) Salivary secretion in neurotic patients suffering from affective disorders (anxiety, depression) is significantly less than secretion in neurotic patients suffering from hysterical and other non-affective disorders. The control neurotic group secreted 1·41 times as much saliva as the affective group.

(2) Salivary secretion in psychotic patients suffering from affective disorders (melancholia, manic-depressive psychosis) is significantly less than secretion in psychotics suffering from schizophrenia and other non-affective disorders. The control psychotic group secreted 1·36 times as much saliva as the affective group.

(3) Men secreted 1·2 times as much saliva as women, a proportion similar to that which the body-size of one sex bears to that of the other.

(4) Salivary secretion is decreased during concentrated mental work. There is about ten times as much secretion during silent reading as there is during the most concentrated mental work.

(5) Food imagery and olfactory stimulation produce a reduction rather than an increase in the amount of salivary flow when the measurements are taken over a long enough period to allow " unconditioning " to take place.

(6) The curve of distribution of the " scores " (i.e. of the total amount of saliva secreted by each patient during the period of the experiment) is not normal, but resembles a J-curve.

(7) The reliability of the test, as measured by retesting a sample of patients after three weeks, is not very high, the correlations between test and re-test being ·54 ± ·15 S.E.

We are indebted to the Medical Superintendents of Mill Hill Emergency Hospital and St. Francis' Hospital for permission to test patients in their respective hospitals.

References.

(1) Eppinger, H. (1917), *Vagotonia: A Clinical Study in Vegetative Neurology.* New York: Nerv. and Ment. Dis. Mon., No. 20.

(2) Sachs, W. (1936), *The Vegetative Nervous System.* London: Cassell.

(3) Guillaume, A. (1928), *Vagotonies, Sympathicotonies, Neurotonies.* Paris: Masson et Cie.

(4) Strongin, E. I., and Hinsie, L. E. (1938), *Am. J. Psychiat.*, **94**, 1459.

(5) *Idem* (1939), *Psychiat. Quart.*, **13**, 697.

(6) Brunacci, B., and de Sanctis, E.(1914), *Arch. di Fisiol.*, **12**, 441.

(7) Lashley, K. S. (1914), *Psychol. Rev.*, **23**, 446.

(8) *Idem* (1916), *J. Exp. Psychol.*, **1**, 461.

(9) Winsor, A. L. (1931), *Am. J. Psychol.*, **43**, 434.

(10) Richter, C. P., and Wada, T. (1924), *J. Lab. and Clin. Med.*, **9**, 271.

(11) Wenger, M. A. (1942), *Human Biol.*, **14**, 69.

(12) *Idem* (1941), *Psychosom. Med.*, **3**, 427; (1942), **4**, 94.

(12a) Wittkower, E., and Pile, W. (1932), *Klin. Wochenschr.*, **11**, 717–18.

(13) Mitscherlich, C. G. (1833), *Poggendorff's An. d. Phys. Chem.*, **27**, 320.

(14) Zebrowski, E. (1905), *Arch. f. d. ges. Physiol.*, **110**, 105.

(15) Brunacci, B. (1910), *Arch. di Fisiol.*, **8**, 421.

(16) Krasnogorski, N. I. (1926), *Jahrb. d. Kinderheilkunde*, **114**, 268.

(17) Winsor, A. L. (1928), *J. Exp. Psychol.*, **11**, 355; (1930), **13**, 423.

(18) Eysenck, M. Davies; *A Statistical Study of Individual Preferences with Olfactory Stimuli.* Thesis, Univ. of London.