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PSYCHO-PHYSICAL INVESTIGATIONS WITH THE GALVANOMETER AND PNEUMOGRAPH IN NORMAL AND INSANE INDIVIDUALS.

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THESE investigations were carried out in the laboratory of the Clinic for Psychiatry at Zürich, to the director of which, Professor E. Bleuler, we are under obligations for the use of apparatus and material for study. The purposes of our

research were to ascertain the value of the so-called "psycho-physical galvanic reflex" as a recorder of psychical changes in connection with sensory and psychical stimuli; to determine its normal and pathological variations; to study the respiratory innervation curve in the same relations; and finally to compare the galvanometric and pneumographic curves taken simultaneously upon the kymograph, under the influence of various stimuli. In word-associations the reaction time was also registered for further comparison.

Chapter I.—Apparatus Employed.

For the respiratory curve we used the Marey pneumograph made by Zimmerman, in Leipzig. The kymograph was made by Schüle, in Basel, and runs with a weight, making it both steady and noiseless. The stop-watch employed for reaction time was manufactured by Billian, of Zürich.

The use of the galvanometer in experimental psychology is so new and recent as to require a special description and a brief review of the scanty literature of the subject.

The first to discover the influence of mental conditions on the galvanometer was Professor Tarchanoff, who published a paper in *Pflüger's Arch. für Physiologie*, 1890, entitled "Galvanic Phenomena in the Human Skin in Connection with Irritation of the Sensory Organs and with various Forms of Psychic Activity." He employed tubular unpolarisable clay electrodes, connected with the skin by means of hygroscopic cotton pads, 10 to 15 cm. long, saturated with saline solution. These are attached to a Meissner and Meyerstein galvanometer. Deviations of the mirror were noted through a telescope upon a scale three metres distant from the galvanometer. The scale was divided on each side of the zero point into 50 cm. and these again into mm. The galvanometer was so sensitive that a nerve stream of a frog's sciatic nerve deflected the mirror so much that all the divisions on the scale were passed over. The electrodes were applied at various times to different portions of the body, such as the hands and fingers, feet and toes, the face,

the nose, the ears and the back. Experimenting thus, he obtained the following results :—

Light tickling of the face, ears, or soles of the feet, with a camel-hair brush or a feather, induced, after a latent period of from one to three seconds, a deflection in the galvanometer to the extent of the whole 50 cm. of the scale. The same results were obtained by stimulating the skin with the faradic brush, with hot and cold water, and by pricking with a needle. Irritation in analogous ways of other sensory organs, the ear, the nose, the tongue and the eye, affected the galvanometer in a corresponding manner.

The experimenter then ascertained that actual irritation was not essential to these results, but the presentation of the proposed stimulus to the imagination also brought about similar deviations in the galvanometer. He stated, furthermore, that the recollection of some fear, fright or joy, in general any kind of strong emotion, produced the same result. The next point of interest recorded by Tarchanoff was that ordinary abstract mental exercise, such as computation, does not affect the galvanometer unless the exercise be accompanied by exertion. He also noted that the emotion of expectant attention or anticipation had a marked effect upon the galvanometer. Tarchanoff regarded the phenomena he observed as due to a secretory current of electricity associated with the sweat-glands. He was evidently unaware of the extraordinary value of the investigations he described in this brief paper. Like many discoveries of importance, his remarkable work lay buried in medical literature for years, and it was not until 1897 that any further contribution on this subject appeared. In that year, Sticker [13] records a repetition of the work of Tarchanoff. His conclusion was that the capillary system of blood-vessels was a factor in the perturbations of the galvanic current. He opposed the idea of Tarchanoff of the centripetal excitation of a secretory current, because he found that the same deviations were noted when the electrodes were applied to anæsthetic and analgesic areas of skin (functional or organic).

After the lapse of five years, Sommer [12] made some experiments with the galvanometer, but lost himself in

technical and physical details, and failed completely to grasp the intrinsically valuable features of the instrument. He observed fluctuations which he attributed to alterations in resistance of the skin or to changes in contact between skin and electrodes. He thought any apparent psychic influence due to involuntary muscular contractions induced by increased pressure on the electrodes, and concluded that, except for the reaction to tickling, no psychic influence on the galvanometer could be established with certainty. He therefore stumbled over, but missed, the one essential point.

About two years ago E. K. Müller, an electrical engineer, of Zürich, read a paper before the Swiss Society of Natural Sciences (medical section) on "The Influence of Psychic and Physiological Phenomena upon the Electrical Conductivity of the Human Body." Happening to make certain experiments upon himself in relation to the resistance of the human body in the alternating magnetic field, he rediscovered the deflectibility of the mirror-galvanometer under psychic and nervous stimulation as established by Tarchanoff.

Dr. O. Veraguth, a neurologist, of Zürich, was then led by Müller to experiment in the same direction. He made use of the Deprez-D'Arsonval mirror-galvanometer, nickel-plated brass cylinders for electrodes, a feeble electrical current, a horizontal celluloid scale on which the light from the mirror registered its movements and an apparatus for photographic delineation of the fluctuations. He published some results last August (1906) in the *Arch. de Psychologie* (Geneva), and he gave the name "psycho-physical galvanic reflex" to the phenomenon.[1] Veraguth corroborates the findings of Tarchanoff. One or two of his experiments are especially striking. If the individual under observation is read to, deviation of the mirror is noted when passages associated with emotional tone are reached. Or, if a series of unrelated words is pronounced, a test suggested to him by one of the authors of this paper (Dr. Jung), words connected with some emotional complex produce an effect on the

[1] Veraguth presented his entire results to date for discussion at the second Deutscher Congress für experimentelle Psychologie in Würtzburg in 1906, the transactions of which will be published early this year (1907).

galvanometer, while indifferent words have no effect He concludes from his studies that only such irritations as are associated with sufficiently intense and actual emotional tone induce a deviation in the galvanometer. He states in his paper that he is not yet in a position to explain the phenomenon, but that if change in resistance were the cause then there are presented manifold contradictions to our present conceptions of resistance in the human body. He did not think it due to alterations in the quantity of blood in the parts beneath the electrodes, for the phenomenon takes place whether the hands be emptied of blood by an Esmarch bandage or supercharged with blood by artificial venous stasis. Veraguth excludes the participation of the perspiration, for the results were similar in hands made dry in formalin.

As far as we know the above review covers the brief literature of the subject, but work has been carried on for about a year in this field in the laboratory of the Psychiatric Clinic at Zürich, the most of which has not yet been published. One of us (Dr. Jung) has published in the *Journal of Abnormal Psychology* (Boston), for February, 1907, the results of association experiments in which the galvanometer was employed, and in this article is a drawing of the apparatus and a description of the order of research. In the same laboratory, Dr. L. Binswanger, together with Dr. Jung, has investigated the physical and physiological problems presented by the phenomenon, the results of which will shortly be published in a separate paper, though the material conclusions of their investigations are embodied in this paper.

The apparatus employed by us is as follows: The mirror galvanometer of Deprez-D'Arsonval; a translucent celluloid scale divided into millimetres and centimetres with a lamp upon it (made by Zulauf & Co., of Zürich), the scale being placed one metre from the galvanometer; a moveable indicator sliding on the scale and connected by a device of Dr. Jung with a recording pen writing upon the kymograph; a rheostat to reduce the current when necessary; and one, sometimes two, Bunsen cells. The electrodes generally used are large copper plates, upon which the palms of the

hands rest comfortably, or upon which the soles of the feet may be placed. We have also used jars of hot water for the contact, when, as with some instances of dementia præcox, the hands were congested and cold. Occasionally we have employed a plate of zinc for one electrode and a plate of carbon for the other (in which case no element was required, since the skin, sweat and metal provided sufficient current).

Chapter II.—The Physics and Physiology of the "Psycho-physical Galvanic Reflex."

So far as has yet been determined, it would seem that the sweat glandular system is the chief factor in the production of this electric phenomenon, inducing on the one hand under the influence of nervous irritation a measurable current or, on the other hand, altering the conductivity of the current. Since water contact excludes changes induced by pressure on metal electrodes, and blanching of the fingers by the Esmarch bandage excludes changes in connection with the blood supply, both of these factors play but a small part in the deviations of the galvanometer. Change in resistance is brought about either by saturation of the epidermis with sweat, or by simple filling of the sweat-gland canals or perhaps also by intracellular stimulation; or all of these factors may be associated. The path for the centrifugal stimulation in the sweat-gland system would seem to lie in the sympathetic nervous system. These conclusions are based upon facts at present to hand and are by no means felt to be conclusive. On the contrary, there are features presented which are as yet quite inexplicable,[1] as, for instance, the gradual diminution of the current in long experiments to almost complete extinction, when our ordinary experience teaches that resistance should be much reduced and the passing current larger and stronger. This may possibly be due to gradual cooling of the skin in contact

[1] On one occasion with three persons in the circuit and one Bunsen cell, the sudden fall of a weight with loud noise caused a deflection of two centimetres.

with the cold copper plates. This can be obviated by warm water contact or by resting the copper plates upon warm sand bags. Yet there is still an inviting field for investigation here.

§ 1.—*Fluctuations of the Galvanometer from Physical Causes.*

If, when the hands are placed upon the copper-plate electrodes, they be pressed down more firmly, there is a slowly-increasing deviation of the galvanometer, but only to a minor degree. If the area of contact be diminished by the raising of the fingers or by lifting of the palms, there is a sudden diminution in the amount of current, marked by sudden reduction of amplitude in the excursion of the light.

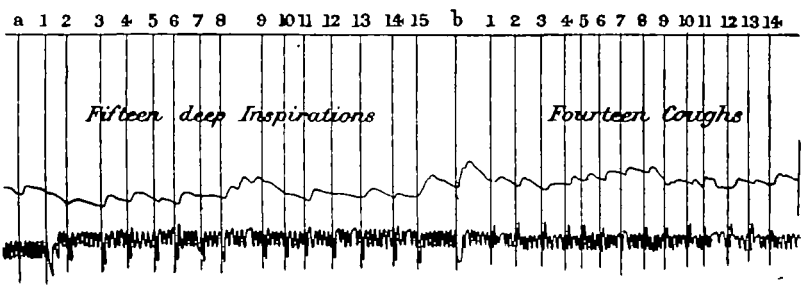

FIG. 1.

Curve to show effects of deep inspirations and coughing upon the galvanometer.[1]

A deep inspiration alone, or a deep expiration, without alteration in the contact of the hands, increases the deflection of the galvanometer, while ordinary respiratory movements do not affect it. Coughing also causes a considerable rise in the galvanometric wave. We are inclined to think that this rise in inspiration and expiration, and with coughing, may also be psychic, that is, emotional. Certainly in the curve we observe exhaustion by repetition of the command to cough or breathe deeply, as in the case of other analogous stimuli. The deviations brought about by altered contact, by deep inspiration and expiration, and by coughing,

[1] All tracings except figs. 9, 14, 15, 18, have been reduced to one-eighth their size.

are all readily recognised after some experience, and are readily differentiated from those depending wholly upon psychic influences. Warm hands naturally permit a larger current than cold hands. The level of the curve rises when the skin in contact grows warmer or moister, and descends with increase of coldness in the skin (see fig. 1).

§ 2.—*Fluctuations of the Galvanometer from Psychic Causes in Normal Individuals.*

Expectation.—As soon as the galvanometric experiment begins, and the circuit through the test person is closed, there is a rather rapid rise with some fluctuation of a curve induced by expectant attention. Tarchanoff was much struck by this. Attention is, as Bleuler [1] has pointed out, nothing more than a special form of affectivity. Attention, interest, expectation, are all emotional expressions. The extent of this expectation curve rises in normal individuals, depending upon their varying degree of affectivity. Expectation is not only manifested at the beginning of an experiment in the galvanometer curve, but may be also observed throughout the experiment in connection with every stimulus, sensory or verbal. It is particularly strong in connection with the threat of pricking with the needle, or threat of letting fall a heavy weight. The influence of expectation on the curve becomes less with each repetition of the same series of stimuli, and seems to disappear wholly with indifferent stimuli; while, with the threat stimuli just referred to, which are more lively and actual, repetition may diminish the curve, or at times increase it if the test case is uncertain whether the threats in the repetition are to be a real prick of the needle or an actual fall of the weight. In beginning an experiment, we therefore wait until the first influence of the emotion of expectation has subsided.

Emotion.—Excluding the affect of attention, we find that every stimulus accompanied by an emotion causes a rise in the electric curve, and directly in proportion to the liveliness and actuality of the emotion aroused. The galvanometer is therefore a measurer of the amount of emotional tone, and

becomes a new instrument of precision in psychological research.

Imagined emotion.—The amount of deflection seems to stand in direct relation to the *actuality* of the emotion; but, as Tarchanoff pointed out, the presentation of an emotion already outlived to the imagination does deviate the galvanometer, such deviation depending naturally upon the facility of the test person in living over the old emotion in his imagination. The following experiment, tried upon one of the writers, is an illustration: The list of stimuli was placed before him, while the reader of the deviations called off at intervals Nos. 1—2—3—4—5—6, allowing time for concentration upon the idea, and for the rise and subsidence of the wave. Between the periods of concentration on the emotional images, the test person allowed his eyes to wander indifferently about the room, and his mind to run on in different objects seen.

An Experiment in the Deflection of the Galvanometer in Imagined Conditions.

	Amount of deviation of galvanometer.
(1) Expectant attention.	
(2) Imagined threat of prick with needle ...	4·3 cm.
(3) Imagined threat of fall of heavy weight ...	1·6 cm.
(4) Imagined grief...	2·8 cm.
(5) Thought of an amusing story	1·8 cm.
(6) Thought of a painful illness in 1888 ...	1·6 cm.

Series of stimuli used.—A series of stimuli, sensory and verbal, strong and indifferent, intellectual and emotional, was arranged and tested upon numerous normal individuals, besides which word associations were used in connection with the galvanometer. In some of the experiments the test person was in an adjoining room, the electric connections and signals being easily adjusted for this purpose. The following is the series of stimuli:—

(1) A loud whistle.
(2) Actual fall of a weight with a very loud noise.
(3) Multiply 4 by 5.
(4) Multiply 9 by 11.

(5) Multiply 8 by 12.
(6) Sudden call of person tested by name.
(7) Where do you live?
(8) What is the capital of Switzerland?
(9) What is the capital of France?
(10) How old are you?
(11) Are you married?
(12) Were you engaged once before?
(13) Have you been long at your present employment?
(14) Threat of prick with needle after counting 1—2—3.
(15) Threat of allowing heavy weight to fall after counting 1—2—3.
(16) What is your first name?
(17) What is the first name of your wife?
(18) Is she pretty?
(19) We have now finished.

The verbal stimuli were varied to a slight degree with various individuals, to adapt them to different conditions and circumstances, but the general character of the stimuli was the same.

These stimuli were ordinarily repeated three times in each individual, normal or pathological, and subsequently the series of word stimuli were given for the word associations, and these were also repeated once or twice. From seventy curves, fig. 2 (H., nurse, Series III.) is selected as a general illustration of the galvanometric curve. This man was emotional and in the third series here presented the curves are smaller and more rounded than in the first and second series. At the same time they serve to show the character of the emotional curve. Stimuli 3, 4, and 5, although they were but simple multiplication, induced an emotional curve, because H. was a nurse and was embarrassed in doing mental arithmetic before experimenters. Stimuli 8, 9, and 10 were practically exhausted in this third trial and show very little. Between 10 and 11 someone entered the room. The weight was let fall twice between 13 and 14 instead of at 2, and being unexpected produced a large and a smaller wave of alarm. The threatened prick of the needle at 14 and threat of fall of large leaden weight at 15 still produced large waves, and show how strongly actuality

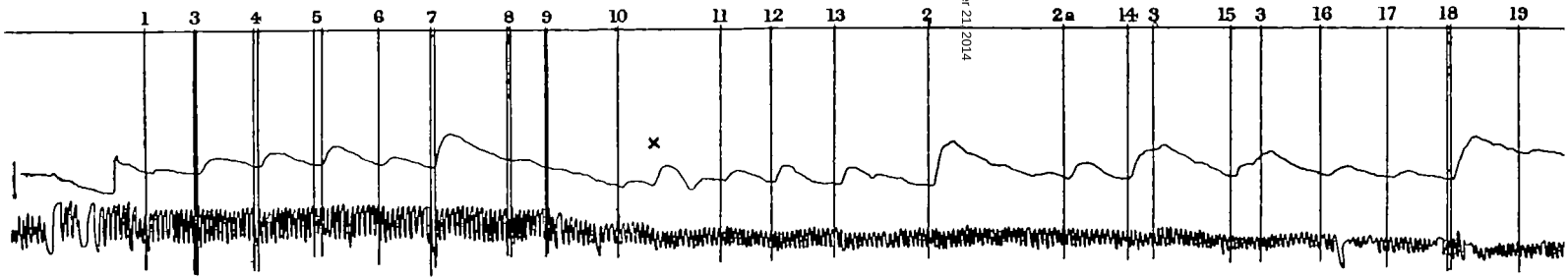

FIG. 2.

Galvanometer and pneumographic curves in a normal person (H., a nurse). The numbers at the top of each stimulus line correspond to the series of nineteen mixed stimuli printed in the text. 2 and 2a representing two falls of the weight occurred between 13 and 14 instead of between 1 and 2 in this curve, which was the second repetition of the series. Between 10 and 11 someone entered the laboratory.

in an apprehension influences the curves. Again, at 18 the enquiry if his wife was pretty, she being far from so, induced a lively emotion and correspondingly high wave, for this question was here a surprise as well, not having been asked in the preceding series.

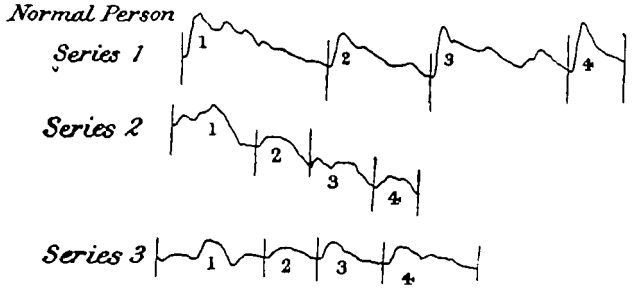

FIG. 3.

Repetition of same stimulus questions in a normal person (H., a nurse) three successive times to show gradual exhaustion of emotional wave in the galvanometer curve. In 3rd series question 1, someone entered the laboratory and caused an extra wave.

Exhaustion of stimulus by repetition.—When the first series of stimuli is recorded, the curves are usually characterised by abrupt ascent and descent with rather sharp summits. The curves diminish in size and the summits

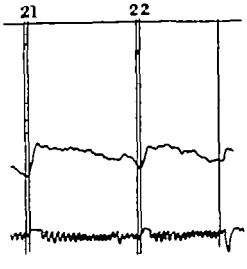

FIG. 4.

Here G., a nurse, is asked about a quarrel with another nurse, H. The fluctuating galvanometer waves 21 and 22 represent the wavering emotions aroused.

become more rounded by each repetition, showing a slower excitation and slower reaction of the emotion. This is well illustrated in fig. 3, where several curves induced by the same stimuli in the first, second, and third series in the same individual are reproduced. Wave No. 1 in Series I.

also exhibits in the descent the fluctuating character of an emotion which is slowly and waveringly passed off. This is even better shown in fig. 4, from Case G., who was asked questions calculated to produce a complex emotional state such as the galvanometer perfectly indicates. In quite a number of instances the heights of the waves of the three successive series were measured and the following two illustrations are selected as examples of the differences in height (in millimetres) of the curves of the stimuli in the three series. Waves were selected which had not been affected in any of the series by interruptions, change of contact, coughing or deep inspirations.

Table 1, *Case of H. Diminishing Excursions of Galvanometer in Successive Stimulations.*

Stimuli. / Case of H.	4 × 5.	9 × 11.	Call by name.	Where do you live?	Capital of Switzerland?	How old are you?	Are you married?	Were you engaged before?	Have you been a nurse long?	Threat with needle.	Threat with weight.	Average.
Series I. ...	34	18	5	38	14	24	18	27	26	36	22	24
Series II. ...	11	12	4	18	9	9	6	4	6	25	59+	10·4
Series III. ...	8	8	4	18	1	3	6	9	9	18	13	8·4

Table 2, *Case of G. Diminishing Excursions of Galvanometer in Successive Stimulations.*

Stimuli. / Case of G.	4 × 5.	8 × 12.	Where do you live?	Capital of Switzerland?	Capital of France?	How old are you?	Were you once engaged?	Have you been a nurse long?	Do you like the work?	Threat with needle.	Threat with weight.	Average.
Series I. ...	9	10	7	7	8	5	10	5	8	17	15	8·6
Series II. ...	6	6	4	7	4	6	4	5	6	14	17	6·2
Series III. ...	3	5	3	5	3	4	6	4	5	16	15	5·4

NOTE.—In the averages of these two tables the eleventh column of figures was not included as the emotion of expectation that the weight would really be dropped modifies especially the second trial, while in the third trial there was less of such expectation.

In these tables the falling off of the height of the emotional curve is very well shown, and in both the livelier affects produced even in repetition by actual threats of the needle and weight are typical. In Series II. of the first table the threat with the weight raised the curve to over fifty-nine because the trial person thought that the weight would actually fall in this experiment, whereas before it was a threat only.

Latent time.—It was noted by Tarchanoff that the galvanic wave began to rise from one to three seconds after a stimulus was given. We have verified this period of latent time in all normal conditions, but the latent time varies with different people and at different times. In the curves that we have thus far taken we could not well complicate the apparatus with a chronograph adjustment, and have estimated the space of latent time in a number of normal cases by measuring the distance of the curve from the moment of stimulation to the beginning of ascent of the emotional curve, taking the measurements in millimetres. The kymograph drum revolved slowly. The following results were obtained. Nurse B. with the series of mixed stimuli given above showed in the first series an average of 2·06 millimetres; the repetition of the second series averaged 2·55 millimetres; with Nurse G. and the same series of mixed stimuli in Series I. the average was 1·85, in the second 1·76, and in the third or final series 2·32 millimetres. Dr. P. with the same series showed an average latent period in the first trial of 3·15, and in the repetition an average of 4·40. Dr. R. with the same series had an average period in the first trial of 4·05 millimetres, and in the second trial of 4·50 millimetres. In a series of word associations Dr. R. showed at first an average period of 2·95 millimetres, and in the repetition immediately after the average was 4 millimetres. With word associations Nurse H. showed in the first series an average latent period of 2·26; in the repetition or second series the latent period was increased to 3·55, and with a third trial of the same words the latent period had become 4·14. These figures with regard to the latent period show therefore that with repetition there is an increase of the

latent period of time simultaneously with the rounding off and diminishing amplitude of the curve, both corresponding with exhaustion of the power of the stimulus. We were unable to determine in this investigation that there was any marked difference in latent time in relation to the various forms of stimulation whether physical or psychic, and when psychic with or without answer to questions or words, though such differences will probably be discovered by further experiment directed to this end.[1]

Normal individual variations of galvanometer curve.— We find considerable difference in the curves made by the galvanometer in normal persons. In some the waves are

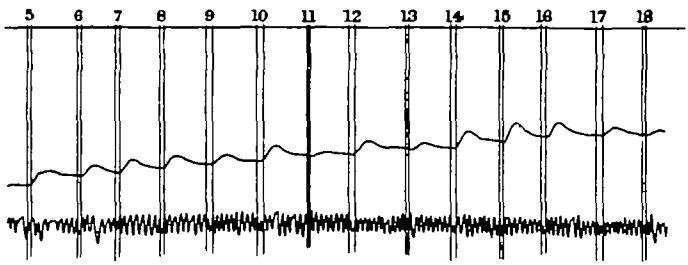

FIG. 5.

Dr. R., normal curve with rather indifferent word-association stimuli. Unemotional type.

of rather small and even excursion, corresponding to the unemotional or phlegmatic nature of the test person. In others there is wide excursion, with fluctuating or bifurcated waves, rapid ascents and descents, expressing great emotional lability. These normal variations are illustrated in figs. 5 and 6.

[1] With a stop-watch we estimated that the time of revolution of the drum was 4·5 millimetres in five seconds. Hence the latent time in the above normal individuals was about as follows:—

Latent time in Seconds.	B.	G.	Dr. P.	Dr. R.	Dr. R. Word Assoc.	H. Word Assoc.
First series ...	2·28	2·05	3·5	4·5	3·27	2·51
Second series ...	2·83	1·95	4·88	5	4·44	3·94
Third series ...		2·57				4·6

Chapter III.—The Pneumograph as an Indicator of Psychic Processes.

The relation of the respiratory innervation curve to psychic processes in both normal and pathological conditions has not yet been thoroughly investigated. Mosso (1879-1893) was one of the earlier investigators in the physiological application of the pneumograph and could reach no satisfactory conclusions from a study of the respiratory curve under sensory stimulation. Delabarre [2] states that respiration increases in frequency and depth with attention to sensory stimulation, and with

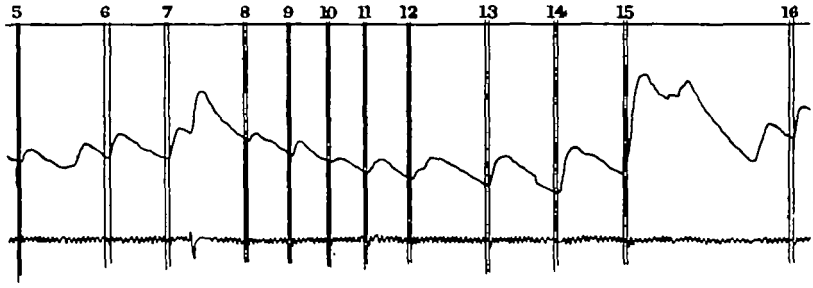

Fig. 6.

H., an attendant, normal curves, very labile emotions. The numbers here correspond to the series of mixed stimuli, 15 is threat of weight.

mental processes increases in frequency and diminishes in depth. Lehmann [7] states that every pleasant impression increases the depth of breathing, and that strong unpleasant impressions are accompanied by several deep respiratory movements. Mentz [9] employed pleasant and unpleasant acoustic stimuli in a study of the pulse and breathing, and as regards respiration observed with strong stimulation first slowing and then shortening of the respiratory movements. He noted also a marked influence of attention on the results. Involuntary attention generally induced prolongation of breathing, while voluntary attention often caused abbreviation of the movements. Pursuing his studies farther he investigated the action of pleasant and

unpleasant stimuli and of the effects upon pulse and respiration. As regards the former, pleasant feelings lengthened the pulse curve and unpleasant ones shortened it, and he regards the respiratory curve as running a parallel course. With affects there was prolongation of the respiratory movements, and with increasing strength of the affects an increasing height or depth of the breathing curve. Zoneff and Meumann [17] finding nothing sufficiently definite in literature in relation to the correspondence between respiration and circulation and psychic or emotional processes, have made an exhaustive research upon normal individuals, employing various stimuli, optic, acoustic, gustatory, cutaneous and psychic (arithmetical problems and space conceptions) and studied at the same time the effects of voluntary attention and pleasant and unpleasant impressions upon the breathing and pulse. They found that as a rule attention produced acceleration of the breathing, especially at the end of the stimulation, and in addition to acceleration the breathing might become more shallow or be inhibited. This inhibition may appear as shallow and more rapid breathing, or there may be a partial or complete standstill of the respiration, and is greater in direct proportion to the degree of attention. Complete inhibition was found more often in attention to sensory than to intellectual stimulation. There were variations in the results in different individualities. There were fluctuations in the curves which they considered as being due to fluctuations in attention. In relation to pleasant and unpleasant stimuli they concluded that all pleasant sensations cause shallowing and acceleration of the breathing, and all unpleasant sensations deepening and slowing of respiration, or, in other words, that the former diminish and the latter increase respiratory function. In experiments with diversion of the attention together with stimulation, they found that emotional effects upon breathing and pulse ceased. In experiments with concentration of attention on stimulus and sensation, attention strengthened the effects of both pleasant and unpleasant feelings upon the curves. While their work is the best that has yet appeared upon this

subject, it must still be confessed that experiments of this nature carried out upon the trained assistants or students connected with the laboratory are more or less artificial, and this, together with the extremely simple character of the stimulation, would make their criteria for the more complex emotional phenomena with which we have to deal only relatively valuable.

Martius and Minnemann [8] in a thoroughly iconoclastic and yet excellent work point out many fallacies in the studies of Lehmann, Menz and Zoneff and Meumann, artefacts of a mechanical nature, and wrong conclusions as to the relations between affects, and pulse and breathing curves. They themselves find the normal respiratory curve inconstant, subject to variations due to age, temperament, perseveration of affect, reactions from the affect, embarrassment from the experiment, undue interest in the procedures, &c., and their chief conclusion is that the main changes in breathing in emotional conditions consist of quickened or lengthened tempo, with diminished height in either case.

Believing that a study of the inspiratory curve would throw the most light upon the relation of respiratory innervation to psychic processes, we set before ourselves several problems for consideration, viz., the character of the usual respiratory curve, the character of the curve in stimulation without verbal reaction, the influence of verbal reaction with indifferent stimuli upon the curve, whether distinct emotional complexes affected uniformly the pneumographic curve, whether there were marked disturbances of the respiratory without corresponding changes in the galvanometric curve, and, finally, what influence attention has on both galvanometer and pneumograph. We have not been able as yet to reach satisfactory conclusions on all of these points, for the material already available is more than we have yet had opportunity thoroughly to investigate; but so far as they go the results obtained are of interest. The figures in the table given below show a regular, though not constant, relation between the galvanometric and the pneumographic curves in one case.

Measurements to Show the Relation in Frequency and Amplitude of Inspirations to Ascending and Descending Portions of the Galvanometer Wave.

Nurse B. Series I.	Whistle.	Weight falls.	4 × 5.	9 × 11.	8 × 12.	Where do you live?	What is the capital of Switzerland?	Are you married?	Threat of needle.	Threat of fall of weight.	Average
Average distance apart of inspirations in the ascending galvanometer curve	2·6	2·83	2·75	2·5	2·2	2·62	2·5	1·87	2·6	2·2	2·46
Average distance apart of inspirations in the descending galvanometer curve	2·18	2·36	2·5	2·14	2·42	2·2	2·3	2·42	2·5	2·3	2·33
Average height of inspirations with ascending galvanometer curve	15·8	15	14·5	14	12·8	11·25	12·5	13·6	16·4	14·6	14
Average height of inspirations with descending galvanometer curve	14·33	13·41	13·75	13	11	9·8	11·7	13	16·4	14·23	13

To obtain these relations it is necessary to select an experiment in which the galvanometric curve has not been influenced greatly by the several sources of error, and the simultaneous pneumographic curve has not been modified too much by verbal reaction, coughing, &c. Taking the typical curves of several such series, measurements were made to determine the relative number of inspirations synchronous with the ascending galvanometer curve, and also with the descending galvanometer curve. The amplitude of each inspiration was also measured and averaged for the same purpose, and the measurements are recorded in millimetres. It will be seen that the ascending portion of the galvanometer curve, which is the result of an emotional stimulus, is accompanied by fewer inspirations as well as by deeper ones. While this seemed to be a general rule in this instance, we find variations in different individuals with the same mixed series of stimuli, and in some cases the reverse.

The stimuli in the table were unpleasant rather than pleasant to the test person. But the determination of the quality of the emotional tone in any such experiment is very difficult. The forced and artificial situation of the test person in itself induces unpleasant feelings, and any pleasant stimulus must therefore simply bring about a certain relief or relaxation in a situation of unpleasant tension. The nervous tension during an experiment must naturally influence the breathing, and a pleasant stimulus is apt to produce only a temporary lessening of such tension. This is a criticism we would make of the Zoneff and Meumann experiments, and of experiments with the pneumograph in general. It is altogether probable that there are more inexplicable influences at work in relation to the pneumographic curve than we are at present able to comprehend. There are many respiratory fluctuations which have nothing to do with the emotions, but are the result of physical or intellectual processes, with the enforced quiet of body of the test person, with the disposition to speak, with tendencies to cough or to swallow, &c. Furthermore, there will be a difference in the curve if the stimulus occurs during an inspiration or an expiration, and there are individual variations dependent upon temperament, upon lability of the emotions.

We have, therefore, not been greatly impressed with the value of a possible relation between the galvanometric and pneumographic curves since it is not constant, and the more we have studied comparatively the two synchronous curves, the more have we been impressed with a surprising divergence between the influences at work upon them. We have studied hundreds of waves in every conceivable manner. For instance, we have taken series of galvanometric curves and carefully measured the length of each inspiration, and the intervals between inspirations, as related to the point of stimulus, to the latent space before the ascent of the galvanometer wave, to the ascending curve, to the crest, to the descending curve, and to the space to the next point of stimulus, without developing any regular and constant relationship or correspondence, though we think this may ultimately be shown to exist in some degree. On the contrary,

we have found thus far that the influences at work upon the two curves reveal an astonishing regularity of difference. When the emotions are very labile, and show the most marked excursions in the galvanometer curve, the respiratory curve is often regular and even (fig. 7). On the other hand,

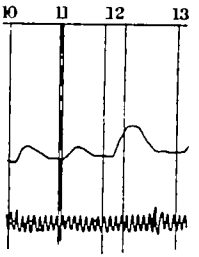

FIG. 7.

Dr. P., normal good-sized galvanometer curves with fairly regular respiratory curve.

in instances both normal and pathological, where the galvanometer curve is marked by little fluctuation, or even by none, as in some cases of katatonia, there will often be most decided variations in the pneumographic curve. We often

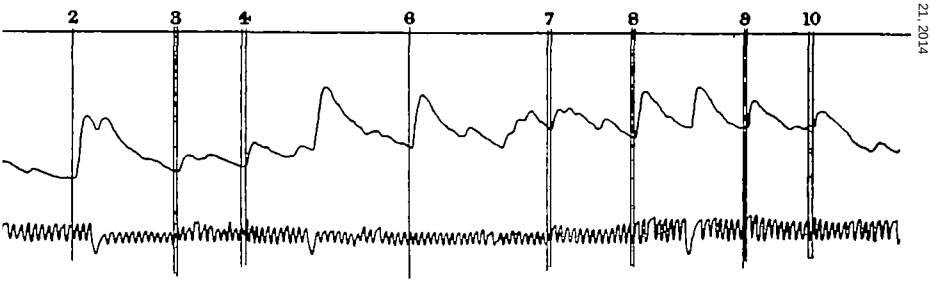

FIG. 8.

Dr. S., a patient with paranoid dementia (Case No. 3). Extraordinary labile emotions expressed in galvanometer curve. Considerable tension in pneumographic curve from stimulus 2 (fall of weight) on, with relaxation and deeper breathing beyond stimulus 7. An example of perseveration of tension for a long period in the pneumographic curve.

note a change in character in the pneumographic curve, not so much with each separate stimulus, but during the whole course of a series of stimuli as if expectant attention and nervous tension diminished the inspirations during the early

part of the series, and as if there were a relaxation during the later half with longer inspirations (fig. 8). There does not seem to be the intimate and deep relationship between the respiratory function and the unconscious emotions that

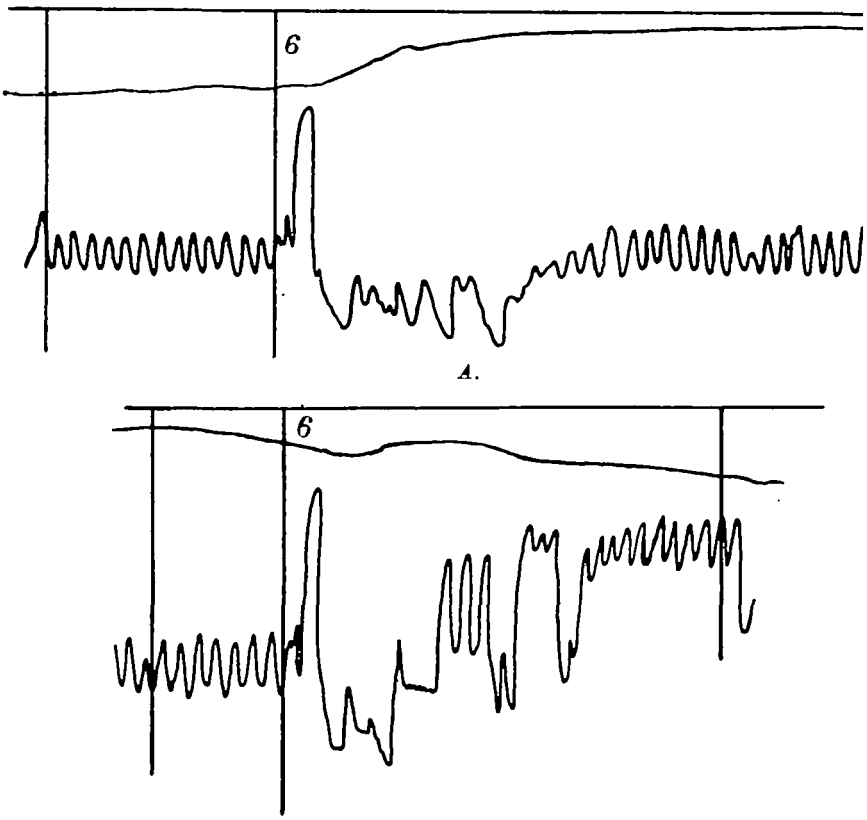

FIG. 9.

J., acute katatonic stupor (Case No. 10). *A* is a wave selected from the series in which 6 is sudden call by name. The galvanometer curve is slight, but the change in the pneumographic curve is notable. *B* is the same stimulus in the repetition of the series.[1]

exists between the sweat glandular system and these emotions. It is a matter of every-day experience that the respiration is influenced by our conscious emotions, especially when they are strong, as instanced in such expressions as

[1] Fig. 9 is reproduced the actual size of the tracing.

"bated breath," "breathless with astonishment," &c. Such inhibitions of breathing are noticeable in many pneumographic curves, particularly in association with expectation and tension. But do, perhaps, the emotions of the subconscious, roused up by questions or words that strike into the buried complexes of the soul, reveal themselves in the galvanometer curve, while the pneumographic curve is comparatively unaffected? Respiration is an instrument of consciousness. You can control it voluntarily while you cannot control the galvanometer curve. The respiratory innervation is closely associated with speech innervation, anatomically and functionally, and the physical connection in the brain is, perhaps, one of the closest and earliest. Let us take these remarkable curves of a case of acute katatonia (figs. 9A and 9B), which may be regarded as a psychological experiment in diverting both attention and ordinary emotion. Attention and all other emotions being practically diverted by the pathological process, the galvanometer curve is slight (indeed, in the *second* repetition it was a straight line), but the sudden call of the patient by name produced the extraordinary fluctuations in the respiratory curve, though nothing was apparent in his outward demeanour to show that he was conscious in any degree of the stimulus. He may have been conscious of the call, but we had no means of determining this. In the repetition the same fluctuations occurred, proving that they were not fortuitous. The only reasonable explanation of this phenomenon, in our opinion, is that the call of the name developed a disposition to speak, stimulated the hearing centre, and the closely-associated speech centre, the motor innervation from which acted upon the respiratory muscles. Ordinarily a sudden call by name, which is one of the strongest and deepest of stimuli, produces an answer. In this instance the call by name was a stimulus that acted as in a simple reflex process, and led to motor manifestations in the respiratory muscles connected with the motor speech centre, analagous to the contraction of the eyelids in response to a sudden flash of light. Fig. 10 is another instance of almost like character.

While inconstancy of emotional variations in the re-

spiratory curve and in correspondence with the galvanometer curve has been the rule in our findings thus far, we have learned that inhibitions, when they occur as an expression of expectant attention or of other emotions, are almost always shown in the expiratory curve and not in the inspiratory, which would accord with our idea that active, intellectual, emotional or conscious innervation is chiefly associated with inspiration, whereas expiration is rather a physical process or relaxation, prone to be inhibited, but not otherwise affected by the active respiratory nerves.

In reiterating our opinion that the galvanometer curve is probably more intimately connected than the pneumographic

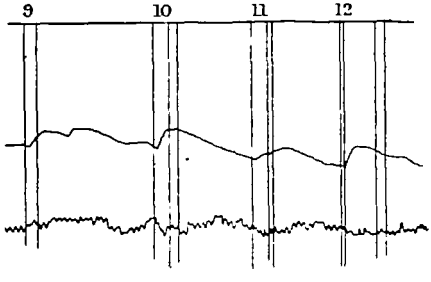

FIG. 10.

Miss S., paranoid dementia (Case No. 2), stimuli 9, 10, 11, 12, correspond to numbers in the mixed series printed in the text. The noteworthy changes in the respiratory curve are due to her constant "disposition to speak." She did not speak except in answer to the questions given, but she apparently whispered most of the time between audible answers. Sometimes there was slight movement of the lips, when real whispering was not apparent.

curve with the subconscious emotional complexes, we would add that there is a greater tendency also to persistence in the pneumographic curve when emotion is expressed in it, for the galvanometer curve subsides rather quickly with the fall of the emotion, while the pneumographic curve may show traces of conscious reminiscence of the emotional stimulus for a much longer time. The galvanometer is rather an index or measurer of acute feeling tone.

Thus far, for the purposes of this study of the curves under normal conditions, we had made some forty series of curves in eight normal individuals, educated and uneducated.

After this we made some thirty series of curves in eleven cases of dementia præcox of different types, viz.: Dementia paranoides three, hebephrenia two, and katatonia six cases (three chronic and three acute), and to these tests we will now turn our attention.

Chapter IV.—The Galvanometric and Pneumographic Curves in Dementia Præcox.

Before recording the results of our experiments in dementia præcox it is necessary to say something of the psychology of the disorder. The chief characteristic in the mental condition of these patients is a peculiar disturbance of the emotions. In chronic conditions we have, as Kraepelin has clearly shown, an "emotional atrophy." In acute conditions there is a species of "incoördination" or "ataxia" between affectivity and concepts, as well demonstrated by Stransky [14]. The emotional disturbance has also been called "inadequate emotional tone." But these phrases represent rather the superficial impression that these patients make upon the physician. As soon as one examines the phenomena analytically and critically, the difficulty of attaining to a common point of view as regards all the morbid emotional symptoms is found to be extraordinary. We see at once that in most cases of dementia præcox all of the emotions are not changed or destroyed. We find, indeed, on closer analysis that many normal feelings are present. Cases with complete loss of all emotion are exceptional. Elementary affects, such as fright, anxiousness, pleasure, anger, embarrassment, shame, &c., are usually preserved. There is even at times an increased affectivity, or real nervous sensitiveness, present. Furthermore, in cases where one would expect more or less diminution of affectivity from their previous conduct and life the elementary feelings are still maintained. The disorder is then shown in what Janet calls the *fonction du rèel*[1] or the psychological adaptation to the environment. It is hardly to be expected that we should find characteristic disturbances in such patients by our

[1] "Acting up to realties."

experimental method (psycho-galvanic), since they would lie in quantitative differences between the various feeling tones. Even were qualitative changes there they would be too small for recognition.

One of the chief factors in psychological adaptation to environment is attention, which renders possible all the associations necessary to normal existence. In dementia præcox, especially the katatonic form, there are marked disorders of attention, which are shown by lack of power of voluntary concentration; or, otherwise expressed, objects do not excite in the diseased brain the affective reaction which alone permits of an adequate selection of intellectual associations. This defective reaction to stimuli in the environment is the chief feature of dementia præcox. But this disorder is not simple and elementary; on the contrary, it is very complicated. What is its origin? There is in the psychology of dementia præcox still another characteristic which throws light upon the problem. By means of word associations and subsequent analysis we find in these cases among other abnormal manifestations certain thought complexes associated with strong emotional tone, one or several of which are fundamental complexes for the individual and embody as a rule the emotions or experiences which immediately preceded the development of the mental disorder. In suitable cases it is possible without much trouble to discover that the symptoms (delusions, hallucinations, insane ideas) stand in close relation to these psychological antecedents. They, in fact, as Freud has shown, determine the symptoms. Freud applied his method particularly to hysteria, in which he found conscious or unconscious constellations with strong affective tone which may dominate the individual for years, or even the whole life through, by their might exerted upon associations. Such a morbid complex plays the part of an independent being, or soul within a soul, comparable to the ambitious vassal who by intrigue finally grew mightier than the king. This complex acts in a particular way upon the psyche. Janet [5] has described it in an excellent manner in his book. The complex robs the ego of light and nourishment, just as a cancer robs

the body of its vitality. The sequelæ of the complex are briefly as follows: Diminution of the entire psychic energy, weakening of the will, loss of objective interest and of power of concentration and of self-control, and the rise of morbid hysterical symptoms. These results can manifest themselves also in associations, so that in the hysterical we find clear manifestations of emotional constellations among their associations. But this is not the only analogy between dementia præcox and hysteria. There are numerous others which we cannot here describe in detail. One may, however, call attention to the large number of undoubted katatonic processes which were formerly called "degenerative hysterical psychoses." There are many cases, too, of dementia præcox which for years are not to be distinguished from hysteria. We call attention to the similarity of the two disorders here in order to show that our hypothesis of the relation between "psychological adaptation to environment," and an emotional complex is an established fact in the matter of hysteria. If we find in dementia præcox similar conditions, we are justified in assuming that here, too, the general disturbances of mind may have a close causal relationship with an underlying complex. The complex is naturally not the only cause of dementia præcox, as little as it is of hysteria. Disposition is also a chief agency, and it is possible that in the disposition to dementia præcox affectivity brings about certain irreparable organic disturbances, as for instance metabolic toxins.

The difference between dementia præcox and hysteria lies in certain irreparable sequelæ and the more marked psychic disturbances from the former disorder. Profound general disturbances (delirium, severe emotional crises, &c.), exceptional in hysteria, are usual in dementia præcox. Hysteria is a caricature of the normal, and therefore shows distinct reactions to the stimuli of the environment. In dementia præcox, on the other hand, there is always defective reaction to external stimuli. There are characteristic differences in relation to the complex. In hysteria with very little trouble the complex may be revealed by analysis, and with a good prospect of therapeutic advantage in the procedure.

But in dementia præcox there is an incapability of being thus influenced. Even if, as is sometimes possible, the complex may be forced to reproduction, there is as a rule no therapeutic result. In dementia præcox the complex is more independent and more strongly detached, and the patient more profoundly injured by the complex than is the case in hysteria. For this reason the skilled physician is able to affect by suggestion acute hysterical states, which are nothing but irradiations from an excited complex, while he fails in dementia præcox where the inner psychic excitement is so much stronger than the stimuli of the environment. This is also the reason why patients in the early stages of dementia possess neither power of critical correction nor insight, which never fail in hysteria even in the severest forms (Raimann [11]).

Convalescence in hysteria is characterised by gradual weakening of the complex till it vanishes entirely. The same is true in the remissions of dementia præcox, though here there is always some vestige of irreparable injury, which, even if unimportant, may still be revealed by study of the associations.

It is often astonishing how even the severest symptoms of dementia præcox may suddenly vanish. This is readily understood from our assumption that the acute conditions of both hysteria and dementia præcox are the results of irradiations from the complex, which for the time conceal the normal functions that are still present. For example, some strong emotion may throw a hysterical person into a condition of apathy or delirium, which may disappear the next moment through the action of some psychological stimulus. In like manner stuporous conditions may come and go quite suddenly in dementia præcox. While such patients are under the spell of the excited complex, they are for the time completely cut off from the outside world, and neither perceive external stimuli nor react to them. When the excitement of the complex has subsided, the power of reaction to the environment gradually returns, first for elementary and later for more complicated psychological stimulation.

Since, according to our hypothesis, dementia præcox can be localised in some dominating psychological complex, it is to be expected that all elementary emotional reactions will be fully preserved, so long as the patient is not in complete control of the complex. We may, therefore, expect to find in all patients with dementia præcox, who show psychological adaptation in elementary matters (eating, drinking, sleeping, dressing, speaking, mechanical occupation, &c.) the presence of some adequate emotional tone. But in all cases, where such psychological adaptation fails, external stimuli will produce no reaction in the disordered brain, and even elementary emotional phenomena will fail of manifestation, because the entire psychic activity is bound up with the morbid complex. That this is an actual fact is shown in the results of our experiments.

The following is a brief *résumé* in each case of the features that have interest for us here :—

(1) H., male, aged 43, teacher of languages. Insane first ten years ago. Well educated and intelligent. Entered an asylum for a time in 1896. Passed through a light period of katatonia with refusal of food, bizarre demeanour and auditory hallucinations. Later always persecutory ideas. In August, 1906, he murdered one of his supposed persecutors, and since then has been in this asylum. Very precise and correct in his dress and conduct, industrious, independent, but extremely suspicious. Hallucinations not discoverable. Diagnosis—*Dementia paranoides.*

(2) Miss S., aged 61, dressmaker. Became insane about 1885. Innumerable bizarre delusions, delusions of grandeur, hallucinations of all the senses, neologisms, motor and language stereotypy. Conduct orderly, neat, industrious, but rather querulous. Is on parole and shows considerable independent activity. Diagnosis—*Dementia paranoides.*

(3) Dr. S., male, aged 35, chemist. Became insane about 1897. Very intelligent and reads numerous scientific books. Has many wants and makes many complaints. Extremely careful in dress, and is extraordinarily neat. Numerous grandiose ideas and hallucinations. No katatonic symptoms. Diagnosis—*Dementia paranoides.*

(4) Mrs. H. O., aged 44, farmer's wife. Became insane in 1904 with an attack of hebephrenic depression. Since the end of

1906 in a second attack of similar character. Speaks only in whispers. Somewhat inhibited, anxious, and hears very unpleasant voices. Works industriously and spontaneously. Neat in dress and in care of her room. Diagnosis—*Hebephrenic depression.*

(5) Mrs. E. S., aged 43, merchant's wife. Became insane in 1901. Occasionally light maniacal excitement, never confusion at first, but rapid dementia. Now greatly demented, inactive, and vexes other patients. Unemotional, indifferent and untidy in dress. Without interest in her husband or surroundings. Chatters a great deal, but quite superficially, and it is impossible in any way to rouse in her any of the deeper emotions. Diagnosis—*Hebephrenia.*

(6) A. V. D., male, aged 39. Entered the asylum in 1897. From the beginning quiet, unemotional, somewhat timid and anxious. Speech fragmentary and indistinct, and talks most of the time to himself. Makes meaningless gestures with the hands. Has to be cared for by the attendant in all matters. Cannot work. Shows neither homesickness nor desire for freedom. Automatism on command and at times catalepsy. Diagnosis—*Chronic katatonic stupor.*

(7) Sp., male, aged 62, factory worker. Became insane in 1865. In the early stages several attacks of katatonic excitement. Later chronic stupor with occasional raptus. In one attack of raptus tore out one of his testicles with his hand. At another time suddenly kissed the attendant. During a severe physical illness at one time he suddenly became quite clear and approachable. Speaks only spontaneously and at long intervals. Works only mechanically when he is led to it. Stereotyped gestures. Diagnosis—*Chronic katatonic stupor.*

(8) F., male, aged 50. Became insane in 1881. At first for a long period depressed inhibition. Later mutism, with occasional outbursts of abusive language on account of voices and numerous hallucinations. At present constant hallucination, though he is quiet, speaking only when addressed, and then in a low, short fragmentary manner. Occasionally outbreaks of abuse because of the voices. Works mechanically, and is stupid and docile. Diagnosis—*Chronic katatonia.*

(9) J. S., male, aged 21. Became insane in 1902. Stupid, stubborn, negativistic, speaks spontaneously not at all or very seldom, wholly without affectivity and apathetic, sits the whole day in one place, wholly disorderly in dress. Once in a while demands release with some irritation. Diagnosis—*Mild katatonic stupor.*

(10) J., male, aged 21, student of philosophy and very intelligent. Became insane about 1901, when he had a short attack. The second attack came in December last (1906). At times excited, wholly confused, and strikes about him. Incessant hallucinations. Wholly wrapt up in his inner mental processes. In occasional intervals of some lucidity, the patient states quite spontaneously that he has no feeling at all, that he cannot be either glad or unhappy, that everything to him seems wholly indifferent. Diagnosis—*Acute katatonic stupor with raptus.*

(11) M., male, aged 26, merchant. Became insane in 1902. At first maniacal excitement. Later dull apathy and occasional exhibition. Then gradually increasing stupor, with complete detachment. Now mutacismus, and tears out his beard, but at other times rigid and cataleptic. Diagnosis—*Acute katatonic stupor.*

The galvanometer curves were in many of the tests with dementia præcox extraordinary. As in normal individuals we found, where there was reaction at all, a gradual exhaustion of the power of the stimulus in repetitions of the same series, so that the waves became smaller in the second, and still smaller and more rounded in the third series. In some cases, where the waves were small in the first series, they disappeared altogether in the third. In fig. 8 we have a good example of a very labile galvanometer curve from a case of dementia paranoides, in which we have abrupt and high ascents, at times with large bifurcations. This was the second series of this patient, and the curves are smaller than in the first. They may be compared with the labile normal curve of fig. 6, which was the first series; and also with fig. 10, another case of paranoid dementia, but in which the galvanometer wave is rather unemotional, while the pneumographic curve shows in this instance such marked changes owing to the disposition to whisper. The type of galvanometer curve, shown in fig. 8, is also characteristic of curves we have taken in hysteria.

In the hebephrenic type there is nothing especially noteworthy in the curve, either in point of great lability or smallness of wave. In the katatonic forms of dementia præcox, especially in the acute forms, we observed, however, extraordinary variations from the normal in the character of the

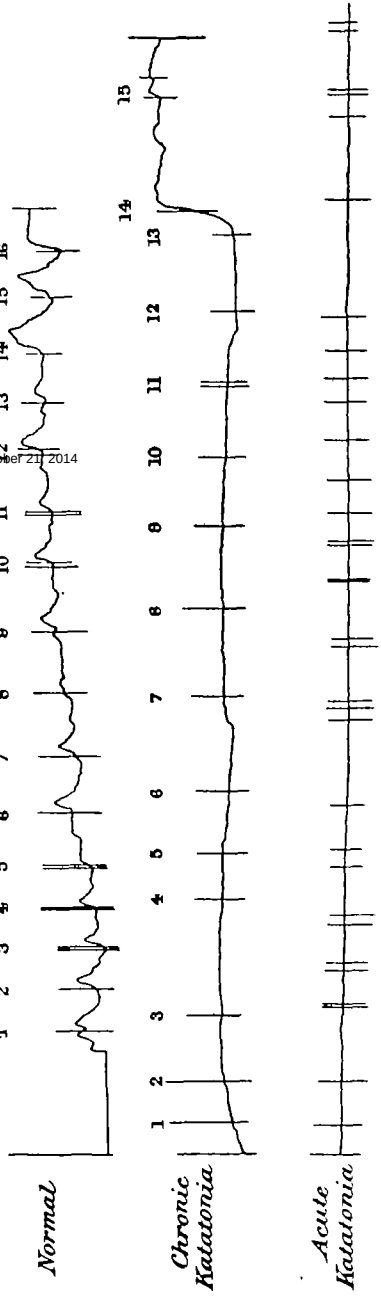

FIG. 11.

Three galvanometer curves for contrast. The first curve is a normal one, with series of mixed stimuli (Miss B., a Canadian). The second curve is that of Sp. (Case No. 7), one of chronic katatonic stupor. Note presence of elementary emotion at stimulus 15. The third curve is that of J. (Case No. 10, acute katatonic stupor). No change whatever in the galvanometer curve to any of the mixed stimuli.

curve. Not only is the latent time longer, but the waves are almost always of gradual ascent, and very small if present at all. Figs. 9A and 9B, from a case of acute katatonic stupor, present illustrations of curves brought about by sudden call of the name. The galvanometer curve is exceedingly slight, but the pneumographic curve shows the singular changes previously mentioned. In fig. 11 we have three galvanometer curves shown. The upper one is from a normal person, with the series printed in the text. The middle one is that of a case of chronic katatonic stupor (Sp.), which is characterised by almost no reaction to any stimuli until 14 is reached, when the threat of sticking with a needle (and the actual stick where the line crosses the up wave) produced a great rise in the curve. A slighter rise occurred at 15, the threat of fall of weight. This is an example of reaction to an elementary emotion in a chronic case where some emotional tone is still present. The lowest line in fig. 11 represents the galvanometer curve of an acute case of katatonic stupor (J.), and here it is seen that the line is perfectly straight, that not one of the mixed series of stimuli printed in the text had the slightest effect; whistle, drop of weight with loud noise, sudden loud call by name, actual hard pricks with the needle—nothing brought out a response in the galvanometer. The pneumograph could not be applied in this case. Our experience with the six cases of katatonia is that such curves are characteristic for the type, and bear out our idea of the psychology of the disease as recorded above.

Another feature of importance in these cases is the matter of latent time. It will be remembered that latent time, before the rise of the galvanometer wave, was estimated by us to vary in normal persons between two and five seconds. In fact, the normal average is three seconds for first series, and 3·77 seconds for subsequent series. In the following tables, one relating to latent space on the kymograph, and the other to latent time, only seven of the eleven cases of dementia præcox appear, for in the others the waves were so slightly marked or so uncertain that the facts could not be satisfactorily determined. One of these patients (Dr.

S.) was tested with both the mixed series and a series of word associations.

Latent Time in Millimetres of Distance from Stimulus to Beginning of Ascent of Galvanometer Emotional Wave in Cases of Insanity.

Names and Diagnosis.	Miss S. Dementia paranoides.	Dr. S. Dementia paranoides.	Dr. S. Word association.	Sp. Chronic katatonia.	A. V. D. Chronic katatonia.	F. Chronic katatonia.	J. Acute katatonia.	M. Acute katatonia
Series I.	3·13	3·75	4·01	3·2	2	4·77	7·16	24·25
Series II.	2·66	3·87	5·81	...	5	5·5	17·3	
Series III.	3·93	4·22						
Series IV.	...	5·46						

Latent Time in the same Cases of Insanity as above Estimated in Seconds.

Names and Diagnosis.	Miss S. Dementia paranoides.	Dr. S. Dementia paranoides.	Dr. S. Word association.	Sp. Chronic katatonia.	A. V. D. Chronic katatonia.	F. Chronic katatonia.	J. Acute katatonia.	M. Acute katatonia.
Series I. mixed stimuli	3·47	4·16	4·45	3·55	2·22	5·3	7·95	26·94
Series II.	2·93	4·3	6·45	...	5·55	6·11	19·22	
Series III.	4·36	4·68						
Series IV.	...	6·06						

In the first case, a woman with dementia paranoides, the latent time is quite within normal boundaries. In the second case, also dementia paranoides, Dr. S., the normal was overstepped only in the fourth round of the same mixed series, but with the same patient with a word association, the latent time was excessive (6·45) in the first repetition of the same words. In the third case, (Sp.), a case of chronic katatonia, the first series showed a latent time of 3·55 seconds, but there were no waves whatever in the repetitions. The four succeeding patients, all cases of kata-

tonia, show increase of latent time, and the two acute cases of katatonia presented an astonishing interval of space and time between the stimulus and the galvanometer wave.

The following table will better show the differences in latent time between the normal and cases of dementia præcox, especially in the averages given at the end of the table.

Comparative Table showing Latent Time in Galvanometer Curve of Normal Cases and of Dementia Præcox.

										Average.	Average of distribution.
Normal	Series I.	2·28	2·05	3·5	4·5	3·27	2·51	...	...	3·01	·73
	Series II. and III.	2·83	1·95	4·88	5	4·44	3·94	2·57	4·6	3·77	·99
Dementia Præcox	Series I.	3·47	4·16	4·45	3·55	2·22	5·3	7·95	26·94	7·25	5·09
	Series II. and III.	2·93	4·3	6·45	5·55	6·11	19·22	4·36	4·68	6·70	3·13

The average of distribution is obtained by subtracting the ordinary average from the larger numbers in the series, or the smaller numbers from the average. The sum of these differences is divided by the number of items, which gives what is called the average of distribution or the average of differences—a useful method of showing wide fluctuations in pathological conditions.

Chapter V.—Association Experiments.

Galton, Wundt, Kraepelin, Aschaffenburg, Sommer and others, have introduced into psychology a very simple experiment, consisting of the calling out of a word to the test person, who must respond as quickly as possible with the first word that occurs to him. The reaction time between the stimulus word and the response, can be measured with a one-fifth second stop watch. It was originally expected that this method would reveal certain intellectual differences in

various individuals. But from the results of investigations carried out in the Psychiatric Clinic at Zürich, it has been found that it is not intellectual factors, but the emotions that play the chief part in determining these associations.

Two persons, of the same social plane, one intelligent, the other unintelligent, even with differences in the character of their intellectual development, may still produce similar associations, because language itself has many general word connections which are familiar to all sorts of individuals belonging to the same circle of society.

There are certain well-marked differences between the word associations of educated and uneducated persons. For instance, the uneducated prefer inner connections with deeper meaning, while the educated very often select simply superficial and linguistic associations. This difference depends, as has been ascertained at the Zürich Clinic, upon the fact that the uneducated fix their attention more closely than the educated upon the actual meaning of the stimulus word. But attention, as has been shown by Bleuler, is nothing more than an emotional process. All affective processes are more or less clearly connected with physical manifestations, which are also to be observed in conjunction with attention. It is therefore to be expected that the attention roused by every association should have an influence upon the galvanometer curve, though this is but one of the affective factors represented in an association experiment.

We observe, as a rule, considerable variation in reaction time, even with practised and quick test persons. One is inclined to explain such irregularities, which are apparently accidental, by supposing the stimulus word to be unusual and difficult, or that the attention is momentarily relaxed for some reason or another. Such may at times be the case, but these reasons are not sufficient to explain the frequent repetition and long duration of certain reaction times. There must be some constant and regular rule to account for them. This disturbing factor has been found at the Zürich Clinic to be in most cases some characteristic thought complex of intrinsic importance for the personality of the test person. The following series will illustrate our meaning :—

Stimulus word.	Reaction word.	Reaction time.
Head ...	Hair ...	1·4
Green...	Meadow	1·6
Water...	*Deep* ...	*5*
Stick ...	Knife ...	1·6
Long ...	Table ...	1·2
Ship ...	*Sink* ...	*3·4*
Ask ...	Answer	1·6
Wool ...	Knit ...	1·6
Spiteful	Friendly	1·4
Lake ...	*Water*	*4*
Sick ...	Well ...	1·8
Ink ...	Black...	1·2
Swim ...	*Can swim*	*3·8*

The four italicised numbers are abnormally long reaction times. The stimulus words are quite ordinary, not difficult, and are such as commonly carry numerous current connections. By questioning the patient, we learn that recently, when greatly depressed, he had determined to commit suicide by drowning. *Water*, *lake*, *ship*, *swim*, were words that excited this complex. The complex brought about lengthening of the reaction time. This phenomenon is quite usual, and is to be observed constantly and everywhere in association studies. Lengthened reaction time may therefore be regarded as a complex indicator, and be employed for the selection from a series of associations of such as have a personal significance to the individual. It is self-evident that associations of this kind are apt to be accompanied by lively emotional tone. The explanation would be simple if the test person were always conscious of the complex which had been excited. But it is extraordinarily common for the test person to be unconscious of the complex disturbed by the stimulus word, and to be unable to answer questions relating to it. It is then necessary to employ the psycho-analytic method, which Freud uses, for the investigation of dreams and hysteria. It would carry us too far to describe here the details of this method of analysis, and readers must be referred to Freud's works [4].

The cause of the interference with the reaction must be sought for in the strong emotional tone of the complex.

Individuals with good powers of introspection often affirm that they could not respond quickly, because of the sudden crowding into consciousness of a number of words among which they could find none suitable for the reaction. This is easily understood, for strong affects always collect numerous associations around them, and, on the other hand, an assemblage of associations is always accompanied by an intense emotional tone. In some cases we have an opposite condition from the above, and the test persons are not able to react because of a vacuum in consciousness, in which event the complex hinders reaction by simply not appearing in consciousness. Thus the underlying thought complex sometimes carries too much into consciousness, and at other times too little, in either case disturbing the uniform flow of psychic functions. It acts like a peace-breaker in the psychic hierarchy. Such being the behaviour of the complex under normal conditions, it is easy to understand how it may play the chief part in abnormal mental states based upon disordered affectivity.

Lengthened reaction time is not the only index of a complex. If the stimulus word causes a sudden embarrassment and brings out some striking and unusual reaction-word, it is certain that a complex has been struck, so that any reaction out of the ordinary may also be regarded as indicating the presence of an emotional thought complex.

It is not infrequent to observe a lengthened or disturbed reaction also in the second reaction after some critical stimulus word, so that we have a persistence of the affect to the next following reaction, a fact which also may be taken to indicate the existence of a complex.

And, finally, we have in the method of reproduction another excellent aid for the discovery of the complex. When the series of stimulus-words has been finished, the list is gone over again, and the test person simply asked to repeat the word he had given before in response to the stimulus. We then notice that where stimulus-words touched upon a complex, the memory plays false and the test person tends to react with some other word than the one first given. This paradoxical phenomenon depends altogether upon the

influence of a strong emotional tone. The complexes are often unpleasant and create a natural resistance in the individual; but they are not always unpleasant or painful, and even with such complexes as the test person would be perfectly willing to reveal, there is yet an inhibition present which shows itself in like manner. The cause of defective reproduction must lie in the general nature of the complex as already described, in a certain independence of the complex, which comes and goes according to factors peculiar to it, and not at the behest of consciousness, and which yields the self-generated associations, and not such as are sought by consciousness. We, that is, our conscious selves, are on the whole in a sense the resultants of competitions in the unconscious.

It is thus that affective factors present themselves everywhere in our associations; and it is of interest to ascertain whether the psycho-galvanic reflex runs a parallel course with the complex indices just described; whether it does so regularly or has a preference for certain constellations; whether differences exist when a complex is conscious or unconscious, &c.

Wherever possible, we have employed the pneumograph at the same time with the galvanometer in these association studies to determine whether parallel disturbances were present.

The association question is many-sided, and there are numerous methods by which to study it. We shall try in the following pages to present our method and to confine ourselves more especially to our method of investigation, rather than to bring forward too prominently results which, owing to the small number of individuals examined, have simply a casuistic value, and cannot be looked upon as having general application.

§ 1.—*The Results Obtained with Association Tests.*

(1) When the experiment is ended we measure the heights of the galvanometric curves and arrange them in a table, with other results of the tests, as follows:—

Case I.—Uneducated man, aged 40, *normal, two series of word associations, each twenty-four words.* (*Nine words given as example.*)

	Series I.				Series II.		
No.	Height of galv. curve in mm.	Reaction time one-fifth sec.	Association.	Reproduction.	Height of galv. curve in mm.	Reaction time one-fifth sec.	Reaction.
1	9	9	Table—chair	ditto	7	7	ditto.
2	4	9	Sit—on a chair	ditto	3	15	ditto.
3	4	11	Garden—vegetable ...	ditto	3	6	ditto.
4	3	14	Red—apple	ditto	4	5	ditto.
5	3	9	Write—with pencil ..	ditto	4	7	ditto.
6	6	40	Full (no reaction)	...	2	6	cask.
7	3	8	Good—sugar	...	9	9	apple.
8	6	6	Forest—wood	ditto	4	5	ditto.
9	5	10	Tavern—drink	ditto	2	5	ditto.

As shown in the table, we made one repetition of the experiment in this instance; in other cases two repetitions were made.

(2) We then determine the arithmetical average of the galvanometric deviations, which in this instance is 4·9 mm. These figures are naturally only relative and, with our apparatus, correspond to only one-half of the actual movement of the mirror of the galvanometer. (The actual figure would be 9·8 mm.).

(3) We then determine the probable average (Kraepelin) of the reaction times in the following manner: The figures are arranged in a column in the order of their size, and the middle number is taken, which in this instance is 1·8 seconds. The probable is here preferred to the arithmetical average, because occasionally very high numbers occur in such tests, where the reaction times are so much more liable to increase than diminution. An arithmetical average would

be unduly influenced by the occasional presence of one or more large numbers, and would not give us the actual average of the reaction time.

(4) In the second series the average of the galvanometer deviations was 4·8 mm., and that of the reaction times 1·2 seconds. We observe, therefore, a reduction in the average height of the galvanometer curve, which is clearly due to lessening of the power of the stimulus in the repetition. The same phenomenon is also seen in the average of the reaction times, which is shortened. The fact that every reaction is accompanied by a galvanometer movement is due to the emotion of attention which accompanies each reaction and is great enough to produce notable physical changes.

(5) We note that in the second series certain associations (the sixth and seventh) are repeated with a change of words. These defective or changed reproductions indicate that the psychological constellation for the respective associations had changed in the short time (a little over one half hour) that had elapsed since the first series had been given. We know that associations which belong to certain complexes are those that may, because of inner conditions, suffer change within a short period of time. We may, therefore, expect that such false reproductions carry with them particular emotional phenomena; and this is actually here the case. The arithmetical average of the altered reproductions is 5·7 mm., while in the first series the average for the same associations was 4·5 mm. Furthermore, the altered reproductions in the second series show an excess of some ·8 mm. over the average of the stimulation of the first series. The average of the reaction times for the altered reproductions is 1·2 seconds, and for the correct reproduction 1 second, as would be expected. We learn from this that the supposition that the altered reproductions are affective phenomena would seem to be justified. We will not here enter into details in relation to the psychoanalysis of such manifestations, as we do not wish to forestall an especially careful study of this question now being made in this clinic by Dr. Binswanger.

(6) From the above consideration one would also expect that those associations which are changed in the repetition should also present some sort of affective signs in the first series; but, contrary to our expectation, we see in this case that the average height of the galvanometer deviation for the words subsequently changed in repetition is 4·8 mm., while the average for the unaltered reproductions is 5 mm. This difference is, of course, small, and no particular deduction could be drawn from one case. It is to be noted that the reaction time (average) for the associations subsequently wrongly reproduced is 1·9 seconds, and for the words correctly reproduced 1·8 seconds. Perhaps there is here a slight indication of the phenomenon to which we refer.

(7) In the preceding paragraphs we have frequently intimated that there is a certain connection between affectivity and the length of reaction time, and this has been already carefully determined in the work of one of us (Jung [6]). One may expect to have, as a rule, large galvanometer curves with long reaction times, always, however, with the limitation that such lengthened reaction times only are considered which are connected with associations that directly excite complexes, and not the long reaction times which may follow immediately after reactions which excite complexes. These latter are frequent as examples of perseveration. In order to discover the actual complex-exciting association it is necessary to employ the psychoanalytic method, and for this purpose a more suitable material is needed than is at our disposition. We, therefore, content ourselves here with simply determining the average height of all galvanometer curves in relation to reaction times which lie respectively above and below the probable average.

In Series I. the average galvanometer curves connected with long reaction times is 4·5 mm.; and with short reaction times 6·1 mm.

In Series II. the galvanometer curves with long reaction times average 5·7 mm.; and with short reaction times 4·4 mm.

The two results are contradictory. The cause of this

lies in factors already alluded to and in other difficulties which must be the subject of later study.

(8) The alteration of the psychological constellation of Series II. already mentioned may be manifested in the galvanometer curve alone, without any change in the reproductions. This matter might be thus explained. In the first trial only certain meanings are attached to the stimulus word by the test person, *i.e.*, not all of the associations belonging to it are excited at the first trial, while at the second trial another series of new connections may be aroused. We very often meet this phenomenon in our psycho-analytic investigations.

It is of the greatest importance for the individual and his intellectual processes to know how his associations are presented to consciousness, whether he has quick and complete command of all related associations. This point is of the utmost value for tests of the intelligence, since many persons may appear to be stupid during investigation because their associations are not at immediate command, and on the other hand stupid persons may seem to be relatively intelligent simply because they have good command of their associations. We may perhaps also expect by this means to discover important differences between educated and uneducated intellects, and the galvanometric experiments seem to open to us endless vistas.

In this case 41·6 per cent. of the associations in Series II. show an increased galvanometric curve with an average plus difference of 2·3 mm. It is possible that later investigations may show us that this result has considerable psychological significance for the individual, because this test person was quite unintelligent.

(9) We observe frequently after a marked galvanometric deviation, that there is an inclination to successive large curves, if the succeeding stimuli are not too quickly given. This is not unexpected because it is a general psychological experience that strong affects induce great sensitiveness (see Jung [6]). If therefore we take the average of the curves which follow unusually strong galvanometer curves and compare them with the arithmetical average of all the

curves, we find that after unusually high curves, the average height in Series I. is 5 mm. and the reaction time two seconds in contrast with the general averages of 4·9 mm. and 1·8 seconds. In Series II. these figures are reversed, for here the average has a plus difference of ·6 mm. while the average of the reaction times shows a minus difference of ·5 seconds. The relations are not quite definite.

(10) The whole of Series I. shows a rather uniform course, for the average of distribution amounts only to 1·6. The deviations are relatively not very high. The highest curve is 12 mm., and the association connected with it is

Stupid—am I

which was for this individual a clear ego-centric stimulus which evidently struck a strong emotional complex.

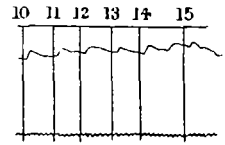

FIG. 12.

Portion of curve in word-associations of a normal test-person.

FIG. 13.

Portion of curve corresponding to the word-association "Stupid—am I."

Fig. 12 is a portion of the curve in this case. In this, one notes the even course and uniform emotional value of each association. The accompanying pneumographic curve is undisturbed.

Fig. 13 shows the portion of the curve in which the association *stupid—am I* (reaction No. 18) occurred. This portion is marked by a very high many-pointed wave. The pneumographic curve is altered here, as it is also in reaction No. 19, though the latter has little emotional tone. But No. 19 has,

however, a very long reaction time (4·8 secs.), which is to be looked upon as a persisting intellectual disturbance from reaction No. 18. We observe here one of the numerous instances where the pneumographic curve and the reaction time show evident disturbances, while the galvanic curve is unaffected. According to our hypothesis, this is owing to the fact that the galvanometer indicates only acute affective conditions, and not the more lasting intellectual after-effects, these latter being often well registered by reaction time and pneumograph. The reaction time shows how long the mind requires to detach itself from its conscious or unconscious pre-occupation, and turn to the new stimulus. The respiration, because of its close relation to consciousness (susceptibility to voluntary influences), is also affected by intellectual processes, while the galvanometer seems to be influenced directly only by the unconscious.

Case 2.—*Uneducated but rather intelligent man, aged* 38.

(1) We have arranged in the following table the results of three series of associations of twenty-four words each :—

Series I.	Arithmetical average of galvanometer curves	5·6 mm.
Series II.	Arithmetical average of galvanometer curves	7·2 mm.
Series III.	Arithmetical average of galvanometer curves	5·9 mm.
Series I.	Probable average of reaction times ...	1·8 sec.
Series II.	Probable average of reaction times ...	1·3 sec.
Series III.	Probable average of reaction times ...	1·0 sec.

The reaction times are what we expect, but the galvanic curves show an unexpected increase in the second series. Our first supposition would be that this is owing to some physical change ; for instance, better contact from increased warmth of the hands, or a change of posture of the body that increased the pressure of the hands upon the electrodes. Such conditions may not only interfere with the experiment, but also render comparison of results difficult. But it is also possible that the psychological constellation changed in the second series, causing thereby greater deviation of the galvanometer. If we take the first fifteen curves of Series II., we find the average to be 4·7 mm., which is much less than the average of Series I. But if we take the last nine curves of Series II., we find the average to be 11·3 mm., and that the

cause of the great difference lies where the principle of loss of power in repeated stimulation does not seem to be effective. It is possible that after the fifteenth reaction there was a physical disturbance, which increased the height of the curves.

We find that the probable average of the reaction times of the first fifteen and last nine reactions both amount to 1·8 seconds, while the average of the galvanometer curves of the first fifteen reactions shows only a minus difference of 0·2 mm., as compared with the last nine curves. Now, if a physical change occurred toward the end of Series II., we might expect no change in the purely psychological reaction times. This is, however, not the case. For the increased galvanic curves in the last nine reactions correspond to an increase of the reaction times (1·4 seconds, as compared to 1 second of the first fifteen reactions). There is, therefore, a parallel between the galvanometer increase and the increased reaction times, from which we may conclude that the increase depends upon an altered psychological constellation.

We have already mentioned that a change in the constellation is owing to the arousing of complexes. The reactions occur in this wise :—

		Series I.			Series II.	
No.	Associations.	Reaction Time.	Gal. Curve.	Reproduction.	Reaction Time.	Gal. Curve.
1	Money—round	1·8 sec.	3 mm.	ditto	1·2 sec.	12 mm.
2	High—tree	1·4 sec.	7 mm.	ditto	1·4 sec.	4 mm.
3	Go out—morning ...	2·0 sec.	8 mm.	ditto	1·4 sec.	6 mm.
4	Floor—dirty	1·8 sec.	5 mm.	ditto	1·8 sec.	9 mm.
5	Wages—large	1·2 sec.	6 mm.	ditto	1·2 sec.	19 mm.
6	Pay—debts	3·4 sec.	9 mm.	ditto	3·0 sec.	15 mm.
7	Apple—red	2·4 sec.	5 mm.	ditto	1·4 sec.	27 mm.
8	Nurses—many	1·6 sec.	4 mm.	ditto	1·8 sec.	5 mm.
9	Five—small	1·8 sec.	5 mm.	ditto	1·2 sec.	5 mm.

While as a rule the reaction times are shortened in Series II., the galvanometer curves are higher. It seems as if the affects first really manifested themselves in Series II. after having been inhibited in Series I. As is shown, the largest increases are connected with the associations, "*money*—round, *floor*—dirty, *wages*—large" (the test person is an attendant or nurse and receives small wages), "*pay*—debts, *apple*—red, and *nurses*—many." It is easy to understand that five of these associations might arouse strong sentiments. The strong reaction with "apple red" is incomprehensible. But we have frequently noticed that quite indifferent associations following immediately upon strong emotional associations show in repetition sudden increase of galvanic reaction, as if the emotional tone were postponed. It is not impossible that we have such a phenomenon here, but we have no means of proving it. Affects are always inhibited if some other strong emotional complex displaces them. This was evidently the case here, because the unusual experiment excited the test person, so that he probably did not grasp the stimulus words in all their personal relations. In Series II. he was more quiet and could comprehend better, in consequence of which emotional tones were more easily developed than before. This phenomenon is theoretically very important, since it indicates how affects are repressed in normal persons. Inhibition of affects plays a powerful *rôle* in psycho-pathology. (See the works of Freud, Bleuler and Jung.)

This experiment also illustrates well that reaction time and galvanometer curve do not mean the same thing. We see here again how clearly the reaction time reveals a greater intellectual freedom than in Series II., whereas the galvanometer curves are considerably higher than those of Series I.

	Galv. curve.	Reaction.
(2) The altered reproductions of Series II. average	6 mm.	... 1·7 sec.
The altered reproductions of Series III. average	7 mm.	... 1·0 sec.
The unchanged reproductions of Series II. average	7·3 mm.	... 1·3 sec.
The unchanged reproductions of Series III. average	5·8 mm.	... 1·3 sec.

Here, too, the relations are somewhat obscure, which may be owing to the occurrence of very few altered reproductions. Only half of the above numbers coincide with our expectations.

(3) Galvanometer curves with long reaction times average in Series I.	6·4 mm.
Galvanometer curves with short reaction times average in Series I.	6·4 mm.
Galvanometer curves with long reaction times average in Series II.	8·1 mm.
Galvanometer curves with short reaction times average in Series II.	4·2 mm.
Galvanometer curves with long reaction times average in Series III.	6·8 mm.
Galvanometer curves with short reaction times average in Series III.	4·1 mm.

The first test is undecided, but the two following present figures which correspond with our expectation. (In Case 1 above recorded the first test also gave a contradictory result.)

(4) In Series II. 41·6 per cent. of the associations show an average plus difference of 3·2 mm. compared with Series I.

In Series III. 45·8 per cent. of the associations show a plus difference of 2·6 mm. as compared with Series II.

These figures prove, as already mentioned, that Series II. presents a considerably altered constellation. In Series III. there are still more psychological constellations changed. It is to be regretted that there was not a much larger material at hand for the farther investigation of matters so important for the psychology of the individual.

(5) Series I. Probable average of reaction times in associations with unusually high galvanometer curves	2·2 sec.
Series I. Arithmetical average of the corresponding galvanometer curves	5·2 mm.
Series II. Probable average of reaction times in associations with unusually high galvanometer curves	1·6 sec.
Series II. Arithmetical average of the corresponding galvanometer curves	12·0 mm.

Series III. Probable average of reaction times in associations with unusually high galvanometer curves ... ... 0·8 sec.

Series III. Arithmetical average of corresponding galvanometer curves ... ... 7·0 mm.

The curves in Series II. and III. do not, while those of Series I. do correspond to expectation. The reaction times in Series I. and II. are what we anticipate. Therefore, of six items, four coincide with our expectation.

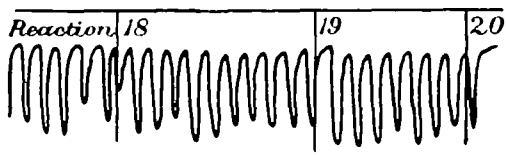

FIG. 14.

Portion of pneumographic curve in Case 2 (word-association, normal individual).[1]

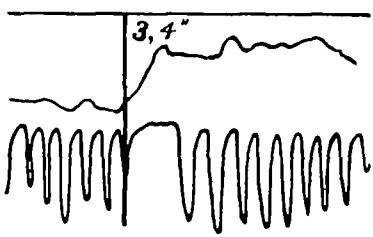

FIG. 15.

Galvanic and pneumographic curve corresponding to the word-association "pay—debts."[1]

(6) Series I. Presents in general a uniform character. The average of distribution is only 1·5 mm. The highest curve measures 9 mm., and this is connected with the association "pay—debts," which, as we have seen, also preserves its high emotional value in Series II.

[1] Fig. 14 and fig. 15 are reproduced the actual size of the tracing.

Series II. is much more irregular. The average of distribution is 3·8 mm., a very high figure, which well illustrates the general irregularity of the series. The highest curves of this series have already been described.

Series III. presents, on the other hand, another series with uniform character. The average of distribution is only 1·8 mm. The highest curve occurs with the association "wages—large," and amounts to 11 mm., and in Series II. it also had a high value. Such concord shows clearly that these figures are not accidental.

The pneumographic curve presents no peculiarities. In Series I., with indifferent associations, this curve has the aspect shown in fig. 14.

Fig. 15 is the galvanometric and pneumographic curve belonging to the association "pay—debts." In this we observe a marked inhibition of respiration during and after the critical association.

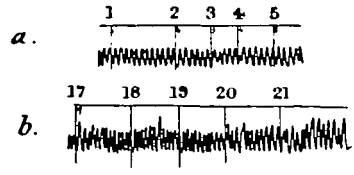

FIG. 16 (*a* and *b*).

(*a*) Respiratory curve, with word-associations No. 1 to 5 in Case 2.
(*b*) Curve, same case, associations No. 17 to 21.

The psychic excitation referred to previously in the last nine associations of Series II. seems to manifest itself also in the pneumographic curve, as apparently evidenced in figs. 16A and 16B.

Fig. 16A is a portion of the respiratory curve during associations 1 to 5. Fig. 16B represents associations 17 to 21. The difference is marked. We can hardly be mistaken in supposing that the change in respiration is the expression of a certain excitation, which is in harmony with our previous assumptions.

Case 3.—*Uneducated man of moderate intelligence, aged* 28, *lively, excitable temperament. Normal. Three series of associations, each with twenty-three words.*

(1) Series I. Arithmetical average of galvanometer curves ... ... 14·2 mm.
Series II. Arithmetical average of galvanometer curves ... ... 6·5 mm.
Series III. Arithmetical average of galvanometer curve ... ... 2·0 mm.
Series I. Probable average of reaction time ... 2·4 sec.
Series II. Probable average of reaction time ... 2·2 sec.
Series III. Probable average of reaction time ... 2·0 sec.

The curves of Series I. reach a considerable height, but the stimulus diminishes rapidly and intensely in power in the succeeding series.

The reaction times shorten uniformly, but are still in general somewhat long, as we observe not infrequently among emotional people.

	Galv.	Reaction time.
(2) The altered reproductions of Series II. average	7·9 mm.	2·0 sec.
The unchanged reproductions of Series II. average	1·8 mm.	2·2 sec.
The altered reproductions of Series III. average...	3·5 mm.	2·2 sec.
The unchanged reproductions of Series III. average	1·3 mm.	2·1 sec.

The galvanic curves correspond in both series to our expectation, but the reaction times in Series II. are contradictory, which, however, is changed if we do not employ the probable average (as is ordinarily done by us in all cases) but the arithmetical average, when the average time for altered reproduction is 2 8 sec., and for the unchanged only 2·4 sec.

(3) The galvanic curves with long reaction time in Series I. average ... ... 17·8 mm.
The galvanic curves with short reaction time in Series I. average ... ... 12·7 mm.

The galvanic curves with long reaction time in Series II. average	9·8 mm.
The galvanic curves with short reaction time in Series II. average	3·6 mm.
The galvanic curves with long reaction time in Series III. average	2·1 mm.
The galvanic curves with short reaction time in Series III. average	0·0 mm.

All of these figures are in perfect accord with our hypothesis.

(4) In Series II. 17·3 per cent. of the associations have an average plus difference of 5·8 mm.

In Series III. 17·3 per cent. of the associations have an average plus difference of 2·8 mm.

These figures show that the constellation in the latter series is not very much changed, with the exception of a few associations. We may conclude that all the strong emotional relations of the stimulus words were brought out in the first test. We should say here that Case No. 3 was well accustomed to this kind of experiment, while cases No. 1 and No. 2 were not.

(5) Series I. Probable average of reaction times following associations with unusually high galvanic curves	2·8 sec.
Series I. Arithmetical average of the corresponding galvanic curves	22·3 mm.
Series II. Probable average of reaction times following associations with unusually high galvanic curves	1·8 sec.
Series II. Arithmetical average of the corresponding galvanic curves	11·4 mm.
Series III. Probable average of reaction times following associations with unusually high galvanic curves	1·2 sec.
Series III. Arithmetical average of the corresponding galvanic curves	1·7 mm.

The galvanic curves are what we would expect in Series I. and II., but not in Series III. The reaction time is what we expect only in Series I.

	Galv.	Reaction time.
(6) Series I. Average of associations altered in subsequent reproduction	14·2 mm.	2·4 sec.
Series I. Average of association unchanged subsequently	13·5 mm.	2·0 sec.
Series II. Average of associations altered in subsequent reproduction	8·7 mm.	2·2 sec.
Series II. Average of associations unchanged subsequently	3·6 mm.	2·0 sec.

All of these figures coincide with what we expect.

(7) The general course of Series I. is very irregular. The average of distribution is 7·6, the highest number we have yet observed. In the tests with Cases 1 and 2 the various phases of stimulation were shown in strong, but much differentiated, emotions, but in this case with lively temperament there was a continual and marked fluctuation of emotions, and hence the high average of distribution.

Series II. is more uniform, and the average of distribution is 5·4, and in Series III. this average is only 2·3.

The highest galvanic curve in Series I. measures 51·5 mm. and is connected with the association "the sun—*burns.*" Why there should be here so strong a reflex innervation could not be understood without further examination. The test person himself could not explain why he had any particular emotion at this moment. But the connection was shown in the following associations. The other high curves (37, 21 and 18 mm.) occurred with the associations "*floor* — parquet," "*pay* — write," "*warm* — the stove." These three associations showed constant and similar disturbances in all three series, as illustrated in this table:—

	Series I.			Series II.			Series III.	
	Galv.	Reaction time.	Reproduction.	Galv.	Reaction time.	Reproduction.	Galv.	Reaction time.
Floor ...	37 mm.	3·0 sec.	ditto	13 mm.	3·2 sec.	ditto	2·5 mm.	3·0 sec.
Warm	18 mm.	1·2 sec.	ditto	31 mm.	2·2 sec.	ditto	7·0 mm.	2·0 sec.
Pay ...	21 mm.	2·0 sec.	ditto	4·5 mm.	0·8 sec.	ditto	7·5 mm.	2·2 sec.

All the reproductions were altered. With one exception all of the galvanometer curves were considerably above the averages for each of the series. As to the nine reaction times, four were above, and two coincided with the probable averages. It seemed justified from these observations to assume that a strong emotional complex lay behind them. But when questioned the test person answered that he had had no particular thoughts in connection with these reactions, and was evidently unconscious of any special complex. Yet even if a test person asserts that no complex is present, this is not conclusive in the face of so many indications pointing to interference by a complex. In this instance we distracted his attention from the matters in hand and asked what personal significance the word "floor" had for him, when suddenly he said with surprise and

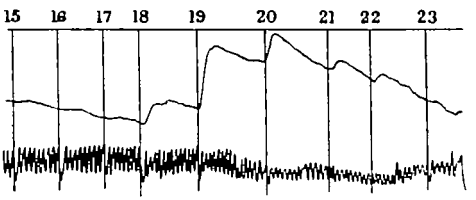

FIG. 17.

Portion of a curve to show emotional effect of certain word-associations.

embarrassment that recently a *stove* in his dwelling had become defective and *burned* the *floor* to such an extent that he had not only to *pay* for a new stove, but also for an entire new floor which was a hardship for him. Besides this there had been great danger from fire. Thus were all the disturbances above related perfectly explained, including the strong emotional tone of the association "the sun—*burns*."

We learn from this interesting episode that the galvanic phenomenon, like reaction time and alteration of reproductions, may give evidence of the existence of an unconscious complex. We cannot go into farther detail regarding this fact here, but the investigations of Dr. Binswanger already mentioned also throw much light on this subject.

The above described group of associations gives an unusually fine picture in Series II. of emotional effect upon the curves (fig. 17). At the beginning we have indifferent reactions. Reaction No. 18 is "floor," 19 "warm," 20 "wages—small," and 21 "pay."

The respiratory curve also shows the reactions very clearly. In general, inspiration is increased which is especially characteristic for this particular case in connection with expectant attention. The condition during the unconscious complex excitation seems therefore to have

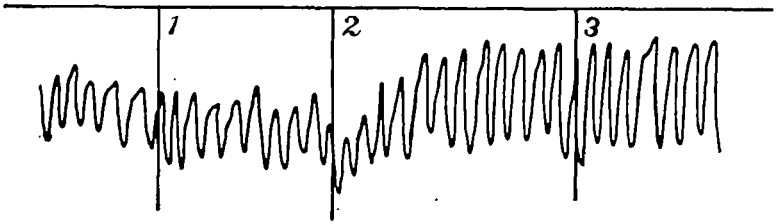

FIG. 18.

Expectation curve in Case 3.[1]

had a certain resemblance to the tension of expectation. An example of this tension of expectation in this case at the beginning of a test is shown in fig. 18.

Case 4.—*An educated woman, aged* 25, *used to these experiments. Three series of word associations, eighteen words in each.*

(*A*) Series I. Arithmetical average of galvanic curves	6·8 mm.
Series II. Arithmetical average of galvanic curves ...	1·9 mm.
Series III. Arithmetical average of galvanic curves ...	0·9 mm.
Series I. Probable average of reaction times	1·2 sec.
Series II. Probable average of reaction times ...	1·0 sec.
Series III. Probable average of reaction times ...	1·0 sec.

The galvanic curves show very rapid diminution, while the reaction time is very short and the lowest limit is soon reached.

[1] Fig. 18 is reproduced the actual size of the tracing.

	Galv.	Reaction time.
(*B*) The altered reproductions of Series II. average	7·5 mm. ...	1·6 sec.
The unchanged reproductions of Series II. average	1·6 mm. ...	1·0 sec.
The altered reproductions of Series III. average	0·0 mm. ...	1·0 sec.
The unchanged reproductions of Series III. average	1·0 mm. ...	1·0 sec.

The result in Series II. is what we expected, but this is not true of Series III., perhaps because only very few altered reproductions occur.

(*C*) The galvanic curves with long reaction times in Series I. average	11·6 mm.
The galvanic curves with short reaction times in Series I. average	5·2 mm.
The galvanic curves with long reaction times in Series II. average...	5·4 mm.
The galvanic curves with short reaction times in Series II. average...	0 8 mm.
The galvanic curves with long reaction times in Series III. average	1·0 mm.
The galvanic curves with short reaction times in Series III. average	1·5 mm.

The figures in Series I. and II. are what we expected, but not in Series III., perhaps because most of the curves had already sunk to zero.

(*D*) In Series II. 5·5 per cent. of the associations show an average plus difference of	6·0 mm.
In Series III. 11·1 per cent. of the associations show an average plus difference of	2·7 mm.

In this case also we note a great readiness of the association to appear fully on the first stimulus, so that the constellation does not change much later on.

(*E*) Series I. Probable average of reaction times following associations with unusually high galvanometer curve...	1·1 sec.
Series I. Arithmetical average of corresponding galvanometer curves	6·5 mm.

Series II. Probable average of reaction times following associations with unusually high galvanometer curves ... ... 1·0 sec.
Series II. Arithmetical average of corresponding galvanometer curves ... ... 1·2 mm.

The figures in Series III. are omitted, because most of the galvanic curves were reduced to zero. The figures given in the above two series do not accord with our expectation.

	Galv.	Reaction time.
(*F*) Series I. Average of associations altered in subsequent reproductions	4·3 mm. ...	4·0 sec.
Series I. Average of associations unchanged subsequently	4·4 mm. ...	1·2 sec.
Series II. Average of associations altered in subsequent reproductions ...	6 mm. ...	1·2 sec.
Series II.. Average of associations unchanged subsequently	1·6 mm. ...	1·0 sec.

These figures are what we should expect.

(*G*) Average of distribution in Series I. ... 5·5
Average of distribution in Series II. ... 2·2
Average of distribution in Series III. ... 1·6

We find as usual the greatest variation in the figures in the first series. With lessening power of the stimulus in the repetitions a levelling tendency is manifested as regards this variation in the power of the stimulus.

The highest curves are found in the following associations:—

	Series I.			Series II.			Series III.	
	Galvanometer.	Reaction time.	Reproduction.	Galvanometer.	Reaction time.	Reproduction.	Galvanometer.	Reaction time.
Ball—dance	4·3 mm.	4·0 sec.	0	7·5 mm.	1·6 sec.	ditto	12 mm.	0 8 sec.
Dress—red ...	9 mm.	1·8 sec.	ditto	2· mm.	0·6 sec.	ditto	0 mm.	0 8 sec.
Pretty—ugly	7·5 mm.	1·4 sec.	ditto	8· mm.	0·8 sec.	ditto	3 mm.	1·2 sec.

The galvanic curves are much higher than the average in all three series for the association "ball-dance." The intensity of the affect here is shown by the fact that while fifteen out of eighteen reactions in the last series caused no deviations of the galvanometer, this particular association induced a deflection of 12 mm. In this instance the test person expected in a few days to go to a fancy dress ball, but despite much search had not yet found a suitable costume. She was, therefore, in a state of anxiety concern-

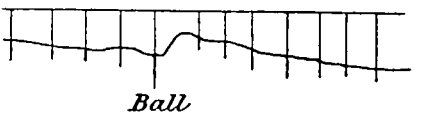

FIG. 19.
Word association "ball—dance" in Case 4.

ing it. The association "dress" and "pretty" are self-evident.

The reaction times were rapidly shortened in the repetitions, because of her natural aptitude in speech. It is evident that at times the galvanic phenomenon is more helpful than lengthened reaction times in demonstrating emotional states.

Fig. 19 is a curve from Series III. in this case representing the well-marked association "ball-dance." Repetition of the association test is to be recommended when one desires to bring out more clearly very strong emotional complexes.

§ 2.—*Résumé of the Tests with Word Associations in Normal Individuals.*

Our limited material, consisting of the word associations in one educated woman and three uneducated men leads us to bring forward with much reserve a *résumé* of our results. We know that they must be regarded as only preliminary, and as being of questionable value, but at the same time they foreshadow features of interest for future enquiry and investigation. Our intention in this work is chiefly to point out indications, and our presentation of results must be taken in this sense.

(1) The average plus difference of a galvanic curve, produced by an association whose reaction time exceeds that of the probable average of the same series, is 2·7 mm.

Taking into consideration the above-mentioned limitations this figure seems to express that in certain cases there is a clear parallelism between the length of reaction time and the height of the galvanometer curve. This method appears, therefore, to afford a psycho-physical proof of the hypothesis of one of us (Jung [6]), that very long reaction times are affective phenomena.

(2) Altered reproductions show an average plus difference of 2 mm. over unchanged reproductions.

(3) Such associations as are changed in the reproductions of the following series present an average plus difference of 6·8 mm. over such as are reproduced subsequently unchanged.

These two figures, especially the last, seem to offer a psycho-physical confirmation of the hypothesis of one of us (Jung [6]), that altered reproductions are affective phenomena.

The remaining methods embodied in the text of our work have little right to a special summing up here, because of the scantiness of our material, and also because of some contradictions in our results.

§ 3.—*Word Associations in Dementia Præcox.*

There were but two of our cases of paranoid dementia that could be used for a test of word associations with the galvanometer.

Case 1.—*Male, aged* 36, *very intelligent, academic education. Speech well preserved. Two series of associations, with twenty-four words each.*

(*A*) Series I. Arithmetical average of heights of galvanometer curve	11·6 mm.
Series II. Arithmetical average of heights of galvanometer curve	4·6 mm.
Series I. Probable average of the reaction times...	6·6 sec.
Series II. Probable average of the reaction times...	4·8 sec.

The average height of the galvanometer curves falls in both series within normal limits, which is not the case with the reaction times, which show excess. Our four normal test persons presented the following average :—

Series I. Galvanometer curves 7·8 mm. Reaction times 1·8 sec.
Series II. Galvanometer curves 5·1 mm. Reaction times 1·4 sec.

From these figures it is seen that the patient offers a strong contrast in the length of the reaction times.

	Galv.	Reaction Time.
(*B*) The altered reproductions in Series II. average	4·7 mm. ...	6·0 sec.
The unchanged reproductions in Series II. average	3·4 mm. ...	2·8 sec.

These figures coincide with the normal, and are what we would expect. But we note that the unchanged reproductions present a much lower value in the reaction time than the altered reproductions.

(*C*) The galvanometer curves with long reaction times in Series I. average	13·1 mm.
The galvanometer curves with short reaction times in Series I. average	10·3 mm.
The galvanometer curves with long reaction times in Series II. average	3·8 mm.
The galvanometer curves with short reaction times in Series II. average	4·0 mm.

In this table the figures in Series I., but not in Series II., are what we expect.

(*D*) In Series II. 12·5 per cent. of the associations show an average plus difference of 4·5 mm.

(*E*) Series I. Probable average of reaction times following associations with unusually high galvanic curves	4·0 sec.
Series I. Arithmetical average of the corresponding galvanic curves	10·0 mm.
Series II. Probable average of reaction times following associations with unusually high galvanic curves	7·6 sec.
Series II. Arithmetical average of the corresponding galvanic curves	3·2 mm.

In this table, only the reaction time of Series II. is in accordance with our expectation.

	Galv.	Reaction time.
(*F*) Series I. The associations with altered reproductions in the following series average	9·8 mm. ...	6·6 sec.
Series I. The associations with unchanged reproductions in the following series average	13·5 mm. ...	5·4 sec.

Only the reaction time here is what we expect.

(*G*) The average of distribution in Series I. was 5·8.

The average of distribution in Series II. was 3·4.

These figures are similar to those of Case 4 among the normal.

The highest galvanic curve occurred with the reaction "love—a psychic process" (30 mm.), and here was also the longest reaction time (27·2 sec.). The next highest curve was connected with the reaction "*wife*-marriage-law" (29 mm.). The patient is single, and having had with "love" a strong emotional tone, it was not surprising that "wife" should also evince a similar intensity. Another high curve was found in the association "*sick*-at-heart" (26 mm.). The patient still had some insight into his condition, and knew that he was confined in the asylum because of his mental malady, hence the strong emotion connected therewith. The word "handsome" produced a curve of 25 mm. The patient is very vain, and pays extraordinary attention to his dress. The contents of the association present the symptoms of affectation, which is evident from his external appearance. Most of his associations showed a definition character which, in educated people, always indicates a certain amount of affectation. The following are examples :—

Write—Activity.
Shoes—Footwear.
Hat—An article of clothing.
House—Building construction.
To sit—Condition of rest.
Money—Medium of exchange.
Proud—Adjective.

The long reaction times may be due to this affected manner of expression, though this can hardly be the only cause.

Case 2.—Woman, single, aged 62, uneducated, medium intelligence. Speech mingled with neologisms. Three series of associations with twenty-five words each.

(*A*) Series I. Arithmetical average of the galvanic curves	7·9 mm.
Series II. Arithmetical average of the galvanic curves	3·6 mm.
Series III. Arithmetical average of the galvanic curves	2·5 mm.
Series I. Probable average of reaction times... ...	10·8 sec.
Series II. Probable average of reaction times ...	6·4 sec.
Series III. Probable average of reaction times ...	6·0 sec.

As in the former case, the galvanic deviations are of medium height, while the reaction times are extraordinarily long.

	Galv.	Reaction time.
(*B*) The altered reproductions in Series II. average	3·6 mm. ...	6·6 sec.
The unchanged reproductions in Series II. average	3·6 mm. ...	5·2 sec.
The altered reproductions in Series III. average	2·5 mm. ...	7·4 sec.
The unchanged reproductions in Series III. average	2·4 mm. ...	4·6 sec.

The reaction times accord with our expectation, as in the former case, much better than the galvanometer curves.

(*C*) The galvanometer curves with long reaction times in Series I. average...	9·6 mm.
The galvanometer curves with short reaction times in Series I. average	6·0 mm.
The galvanometer curves with long reaction times in Series II. average	4·7 mm.
The galvanometer curves with short reaction times in Series II. average	2·6 mm.
The galvanometer curves with long reaction times in Series III. average	2·8 mm.
The galvanometer curves with short reaction times in Series III. average	2·5 mm.

The figures in all three series are what we expect.

(*D*) In Series II. 28·0 per cent. of the associations show an average plus difference of 4·7 mm. In Series III. 24·0 per cent. of the associations show an average plus difference of 4·8 mm.

(*E*) Series I. Probable average of reaction times following associations with unusually high galvanic curves	11·6 sec.
Series I. Arithmetical average of corresponding galvanic curves	11·8 mm.
Series II. Probable average of reaction times following associations with unusually high galvanic curves	5·8 sec.
Series II. Arithmetical average of corresponding galvanic curves	3·7 mm.
Series III. Probable average of reaction times following associations with unusually high galvanic curves	8·0 sec.
Series III. Arithmetical average of corresponding galvanic curves	2·5 mm.

Twice the reaction times are what we expected, the galvanic curves only once, and in Series III. the arithmetical average is the same.

	Galv.	Reaction time.
(*F*) Series I. The associations with altered reproductions in the following series average	9·0 mm. ...	10·4 sec.
Series I. The associations with unchanged reproductions in the following series average	6·3 mm. ...	12·4 sec.
Series II. The associations with altered reproductions in the following series average	3·3 mm. ...	6·6 sec.
Series II. The associations with unchanged reproductions in the following series average	4·0 mm. ...	4·8 sec.

We find in this table that only the galvanic curves in Series I. and the reaction times in Series II. are what we expected.

(*G*) The average of distribution in Series I. was 4·9.
The average of distribution in Series II. was 2·8.
The average of distribution in Series III. was 1·6.

The highest galvanic curve (21 mm.) is found in the association "sun—sun-time," and here the reaction time is 14·0 seconds. It is difficult to explain this excessive deviation. The preceding association is "stout—constitution" (15 mm., and 14·8 seconds reaction time). The patient is very stout, which she thinks due to supernatural influences. She complains much of this "forced" disfigurement. In Series II. these two associations caused no deviations, but in Series III. "stout—constitution" suddenly induced the largest deflection of the whole series, viz., 14·5 mm., whereas the average was only 2·5 mm. There was a curve of 20 mm. with the association "ugly—disfigured by great suffering," and with this a reaction time of 12·0 seconds. The contents of this association are concerned with the same theme as "stout—constitution." Another high curve occurred with "high—highest action" (19 mm. and reaction time 11·2 seconds). This association was subsequently altered twice in the reproductions. It is connected with the delusion of the patient that she had accomplished the "highest work."

The associations are typically affected and show a distinctly morbid character.

The following are examples :—

Diligent—High esteem—Payment.
Love—To be lovable—Wedding.
Snake—To point out as extraordinary.
High—Highest action—Highest distinction.
Ugly—Disfigured by great suffering.

Résumé : In our tests with word associations in the two cases of dementia præcox the only striking fact has been the great lengthening of reaction times. In the relations between the galvanometer curves and associations we have found nothing different from the normal. From the material of Jung, who has analysed a large collection of association experiments in dementia præcox, we learn that in by far the greater proportion of these cases there is no particular lengthening of reaction time. Therefore a long reaction time cannot be considered as characteristic for all cases

of dementia præcox. It is of value in some cases. It is only present when the patients suffer from certain hindrances to thought, which are often present in this disease.

When we examine the associations of such patients we find that the hindrance to thought (lengthened reaction time) is especially manifested where complexes constellate the association, which is also the case in normal individuals. This phenomenon first led Jung to think that the specific pathological factor in dementia præcox depends upon some complex. A complex in fact plays a great *rôle* in the associations of our two patients here described. The reaction times are extraordinarily long where connected with a complex. The complex constellations are also very numerous, as well as the altered reproductions related to them. In our normal cases we found an average of 30 per cent. of altered reproductions in Series I., while the patients had 51 per cent. Besides this, the character of the associations presents abnormalities almost constantly, especially around the complexes.

From these indications we may conclude that little of a pathological nature can be found in the general and regular mechanisms of thought, but rather in the manner and method of reaction of the individual to his complexes. We find in both of these patients an increased influence of the complex upon association, which corroborates the results of innumerable analyses of dementia præcox by Jung. This phenomenon has an important and general clinical significance, because, when carefully analysed, nearly all the symptoms are found to be determined by an individual complex, often manifested in a very convincing way. This is particularly true for delusions and hallucinations. A series of other symptoms is more often dependent upon indirect disturbance of association by the complex. This state of affairs explains why we do not discover any elementary disturbances, even in quite intense mental disorder; the dementia is shown only in the most delicate psychological relations. Therefore we shall look in vain, for the present and for a long time to come, among these patients for simple, elementary disturbances common to all cases.

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Note.—Since this article was put into type we have found that Féré [3], carrying a current through a test person with various sensory stimuli, made the following observation: "Il se produit alors une déviation brusque de l'aiguille du galvanomètre . . . . La même déviation se produit encore sous l'influence d'émotions ethéniques c'est à dire qu'elle se produit dans toutes les conditions ou j'ai signalé précédemment une augmentation de volume des membres mise en évidence par le pléthysmograph." This clearly shows that Féré made the discovery two years before Tarchanoff.