AN EXPERIMENTAL STUDY OF THE OCULAR REACTIONS OF THE INSANE FROM PHOTOGRAPHIC RECORDS.

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WITHIN the last few years exact knowledge of the normal movements of the eyes has made rapid advance, particularly in America, through the use of mechanical and photographic registering devices. Quantitative information is now at hand with respect to the angle-velocity [2, 3, 9][1] and the path of the line of regard during rapid eye-movements [4-6, 8, 10-16],[1] the accuracy, stability and variability of fixation under a considerable variety of circumstances [4, 6, 8, 10-15],[1] the ocular reaction-time [8],[1] and the peculiar modifications of eye-movements which constitute short-lived motor habits [5],[1] pursuit movements [7],[1] co-ordinate compensatory eye-movements [7, 8],[1] and the movements of convergence [12].[1]

The ease with which the photographic technique can be adapted to a wide variety of experimental requirements, together with certain peculiarities of the eye-movements themselves, led the writers to believe that a comparative study of the eye-movements of normal and insane persons might be made a fruitful contribution to our experimental knowledge of the reactions of the insane.

Such a comparative study might well find its basis in any of a large variety of experimental data. The present investigation was limited to three main problems, which were relatively clear to us, and to meet which we framed our technique.

The difficulties in any experimental study of normal psycho-physical processes are serious enough, even though one may rely on the highest

[1] Numbers 1 to 16 refer to the bibliography at the end of the paper (pp. 488, 489).

degree of intelligent coöperation on the part of the subject. In the study of abnormal mental life, additional difficulties arise from the very nature of the object of investigation, in direct proportion to its variation from the normal. As Kraepelin cogently observes, lack of comprehension of the experimental test, lack of ability to execute it, lack of interest, coöperation, and of endurance, all conspire to increase the task of the experimenter and to modify the value of his results. The consequent demand for trustworthy experimental methods, which, without too complicated technique or too unusual demands on the patient, shall yield quantitative information of significant variations from normal reactions, voices at once the need and the embarrassment of experimental psychiatry. These demands are met in part at least by the reactions of the eyes as they are known through their photographic records.

Eye-movements are neither unusual nor difficult. On the contrary, the ability to look at a bright object which appears suddenly within the field of view is one of the earliest forms of motor organization to be achieved, and it is retained long after the ability to learn new and complex forms of reaction is irretrievably lost. A patient will naturally look at a suddenly appearing object when he could learn the simplest new reaction only imperfectly and with enormous waste of time.

Moreover, while the eye-movements are intimately associated with the most complex mental activities, they are peculiarly inaccessible to subjective observation. Even the best trained observers utterly failed by introspection to discover some of the facts of eye-movements which are most conspicuous in the photographic records. For the ordinary man, his eye-movements are usually involuntary and unconscious; they are essentially a part of the mechanical preadjustments of vision, and consciousness is concerned with the result rather than the preadjustments. They may on occasion be consciously initiated, but once begun they are entirely withdrawn from conscious control. This effectually prevents both arbitrary modifications and successful simulation of pathological symptoms. Moreover, relative uniformity in the previous training gives unequalled opportunity for legitimate comparison between different persons. Probably no other form of reaction is common to so many different persons in so high a state of development. The nearest competitor in this respect are the various speech functions; but gross differences of individual habits and training render generalization concerning the latter more difficult. In the eye-movements, on the other hand, we may reasonably assume almost complete identity of practice and a general high grade of efficiency.

Finally, the technique of recording the eye-movements is relatively simple. By using the corneal reflection as the registering medium, there is absolutely no discomfort to the patient and no unusual stimulus to excite him, while the real purport of the experiment may be entirely hidden under the instructions to the patient to read exposed figures, letters, or short words, or simply to try if he can see anything at all on the black screen.

On the other hand, the photographic procedure is not without some difficulties of its own. The eyelid may droop and interfere with the recording light without parallel interference with vision. Excessive head-movements may render a considerable portion of the plate illegible or take the patient out of focus of the recording camera. But the records themselves are their own vindication, and we venture to believe that those who can appreciate the experimental difficulties of securing trustworthy comparative data will find some satisfaction in our results, and reasonable ground for expecting more of the general procedure in the future.

The most serious limitations of our technique arise from defective vision. Just how far this may finally be found an embarrassment it is difficult to predict, since the technique permits some use of correcting glasses. The series of experiments we undertook was planned to render a considerable range of visual defects indifferent; nevertheless, in three cases we were compelled to abandon the tests because of gross refractive errors.

For both of us the most surprising feature of the experiments was the conduct of the patients during the tests. We anticipated a considerable variety of troubles, particularly from the maniacal patients, and safeguarded the apparatus in a number of entirely unnecessary ways. Naturally the worst cases of maniacal excitement were not requisitioned; but, as will later appear in detail, we succeeded in getting excellent records from patients that in the wards appeared utterly impossible.

In only two cases did we encounter any unwillingness to participate in the tests. Something about the experiments seemed to appeal to the patients. The majority were helpful in getting into position and maintaining it. Many seemed thoroughly to enjoy the sessions; some were interested in the results; some were more sensitive than others to the blue light, as was evidenced by an occasional increased tendency to wink or to withdraw entirely from the apparatus, but the light was stopped down by blue glass so that continuous fixation produced only a mild and inoffensive after-image. Many of the patients apparently failed to notice it.

Apparatus and Technique.

The registering device for recording the eye-reactions was a modification of the Dodge photochronograph which was designed by one of the authors, and has been used by him practically in its present form during the last five years.

As used by us it consisted of an enlarging camera of fixed length (about 5 ft. [153 cm.]) fitted with a Bausch and Lomb convertible protar, Series VIIa. The device for producing a regular motion of the sensitive photographic plate was the Dodge-Cline falling plate-holder. It consists of a light-tight box 2 ft. (61 cm.) high and 7 in. (17·8 cm.) wide, fitted with opaque slides, and capable of quick adjustment to the rear of the enlarging camera like a regular plate-holder. Within the box a movable frame, holding a 5 in. (12·7 cm.) by 7 in. (17·8 cm.) photographic plate, slides vertically on two brass tracks, so adjusted that all lateral play is taken up by springs. The movement of the sliding plate frame is accurately controlled by a simple hydrostatic device. The frame is attached to a piston-rod ending in a plunger which works in a vertical cylinder of lubricating oil. The valve of the plunger offers no resistance as the latter is raised through the oil, but it absolutely resists every effort to force it downwards. The release of the plate is effected by opening a stop-cock below the plunger, when the weight of the plate-holder forces the oil out of the cylinder at the bottom through the stop-cock, and returns it to the top of the cylinder above the plunger. The velocity of the fall is determined by the opening of the stop-cock, the viscosity of the oil, and the weight of the frame and plate.

The photographic record is made on the falling plate by photographing the image of an electric arc as it appears at the cornea of the eye. The rays of the arc light are first passed through blue glass screens to eliminate the photographically useless but physiologically disturbing rays of the lower spectrum. Those rays which are then reflected from the convex surface of the cornea to the camera are brought to a focus on the photographic plate by the lens of the enlarging camera.

A convenient and well-nigh necessary modification of the plate-holder was introduced for the first time in the present experiments. Since one cannot presuppose much coöperation on the part of the insane in finding and maintaining the proper position of the head, it was found impossible to rely on methods of focusing that were satisfactory for normal subjects. A focusing and finding glass was consequently introduced into the falling plate-holder just below the photographic plate, and in the same plane. A system of automatic

screens was arranged, so that during the focusing process the plate was entirely protected from light. In this way we could quietly await the opportune moment and quickly adjust the apparatus to changes in the patient's position. The apparent movement of the corneal reflection is slightly less than half the actual movement of the eyes.[1]

But the actual displacement is magnified by the enlarging camera so that the total record is a continuous curve whose amplitude is about three times the actual amplitude of horizontal eye-movements, and whose height is determined by the velocity of the plate. Under the above circumstances, continuous visual fixation will be recorded as a straight vertical line on the falling plate, while any horizontal movement of the eyes will be indicated by an oblique line whose obliquity depends on the relative velocity of the horizontal and vertical components.

The difference in illumination between the corneal reflection of the arc light and its background is sufficiently marked, so that on a perfect plate there is no trace of other impressions except the record made by the corneal image of the arc light. This should appear as a fine black hair-line on an almost clear background. No limit has been reached in the number of records one plate will hold, except the purely mechanical confusion of the lines.

In our experiments the stimulus was so arranged as to begin coincidently with the beginning of the record. When the velocity of the plate is known, the duration of an eye-reaction will be given by the height of the vertical line of eye-fixation between the beginning of the record and the beginning of the oblique line of eye-movement. The velocity of horizontal eye-movement should be given by the obliquity of the line of eye-movement, *i.e.*, the time, as measured by the fall of the plate, between one fixation and its successor.

Two series of records were made. One depended for its time-record on the measured length and obliquity of the lines. In the other an interruption of the recording light by a tuning-fork gave the time directly in vibrations of the tuning-fork. Notwithstanding a complex system of controls, our first records of the angle-velocity of the eyes by the former method involved such serious sources of error that we were reluctantly constrained to abandon them as practically useless. They do not appear in this report. The reaction-records, on the other hand,

[1] For the mathematical theory of the movements of the corneal reflection and empirical tests of its accuracy as a measure of eye-movements, *see* Dodge: "Experimental Study of Visual Fixation" [8].

were about equally satisfactory in both series. Each record involves a probable error of less than 0·01 second.

In convenience of control and in general trustworthiness the tuning-fork interruption of the recording light is a decided advantage. It was arranged as follows:—

An arc light, with horizontal upper carbon, was mounted on a heavy optical bench behind a large condensing lens. In front of this lens, and at the point where the latter brought the rays of the arc light to a

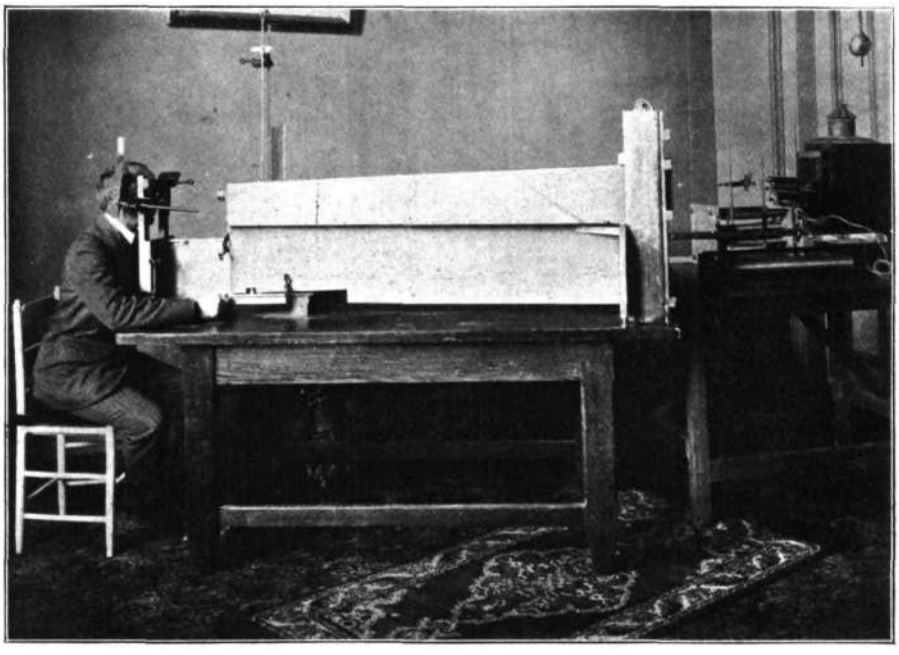

FIG. 1.
The Dodge Photochronograph.

focus, was placed an opaque screen with an opening which was so shaped and oriented that at each vibration of an electric tuning-fork (a tested Koenig tuning-fork of 100·12 c.-p. per second) the opening was alternately opened and closed to the passage of the light from the arc. A second smaller lens of 6 in. focus was so placed as to render the transmitted rays parallel. From the position of the subject one isolated vibration of the fork exposed the arc light and cut it off again. With this interrupted light, when the tuning-fork was in continuous vibration,

each record of the corneal reflection appeared on the slowly falling photographic plate as a line of black points or dashes. From the beginning of one dash to the beginning of the next represented a time interval of 0·01 second. The duration of any fixation or of any eye-movement could be read directly from the appropriate record in units of 0·01 second by counting the corresponding dots.

The arc light and the tuning-fork interrupter were placed in one corner of the laboratory at a distance of about 15 ft. (459 cm.) from the patient. The patient was seated comfortably at the apparatus just in front of the enlarging camera. His head was held as firmly as practicable against a side-rest and a nosepiece. Further constraint seemed inadvisable. The resulting records were considerably complicated by head-movements, but our immediate interest was not a study of the spatial characteristics of the eye-movements, but rather a study of their temporal succession. For this purpose the records were unequivocal, except in a few cases. No patient was in the apparatus more than thirty minutes. Under favourable circumstances the tests occupied about fifteen minutes, including periods of relaxation. All records are for monocular vision. A black cardboard screen completely hid the unused eye. Three groups of tests were made on each patient at each sitting, and all three groups were recorded on the same plate. In this way each plate made a complete experimental record of a single patient at the time of examination. The plates were carefully numbered, and each number was entered in a permanent record against the name of the subject, with such additional notes of the clinical picture and conduct of the patient as seemed pertinent.

The experiment which we undertook included three tests for distinct but inter-related phenomena.

(1) Velocity of Eye-Movements.

(A) *Theory.*

The first test concerned the angle-velocity of simple reactive eye-movement. Experiments on normal individuals have shown a remarkable uniformity in the angle-velocity of similar uninterrupted eye-movements of the same person, quite independent of direct conscious effort to move the eyes fast or slowly. There are slight variations of the two eyes, and slight variations in successive movements, but under similar circumstances these variations are relatively small.

The first published records of the angle-velocity of the eye-movements noted a slight but clear slowing up of a rapid succession of eye-movements toward the end of a series of ten movements. This was tentatively attributed to fatigue. A series of records taken in connexion with a hitherto unpublished study of fatigue confirmed the previous findings and justified the hypothesis that retardation of the velocity of the eye-movements is a phenomenon of fatigue.

Valuable as they undoubtedly would be, it was hardly to be expected that adequate fatigue tests could be obtained from the insane. On the other hand, it seemed plausible that the different disease processes, in so far as they affected the psychomotor processes at all, would variously affect the angle-velocity of the eye-movements. It also seemed probable that such variations in a type of movement which is equally practised for all subjects and is almost entirely removed from the effects of voluntary caprice, would furnish exceptionally trustworthy comparative data.

Naturally, our immediate interest centred in patients suffering from maniacal-depressive insanity, where, as a matter of fact, the most marked variations from normal velocity were found, but the results of the test in other disease-processes are not without interest.

(B) *Experimental Conditions.*

The test for the angle-velocity of the eye-movements necessitated the experimental production of a considerable number of rapid reactive eye-movements of the first type (Dodge [7]) of approximately the same amplitude. Taking advantage of the fact that rapid eye-movements separate the fixation-pauses (or moments of clear vision) in reading, we satisfied the experimental requirement by exposing a succession of isolated numerals in two different parts of the field of regard about 25° apart. The reading of one numeral by the patient was the signal for the operator to cover it and to expose another 25° from the former. When the latter was read, it in turn disappeared and another was exposed where the first had been.

The eyes rarely moved through the entire 25° from numeral to numeral in a single rapid eye-movement. This was entirely congruent with the known facts that practically every long eye-movement involves more or less final readjustment in the form of short corrective movements. When the object of interest is relatively obscure, like a numeral 25° from the fixation-point, the normal end-corrective movements will vary from 1° to 5°. In the great majority of cases the corrective

movement is in the same direction as the initial movement. This indicates that the initial movement was too short. If the corrective movement was negative, or if it exceeded one-sixth of the total displacement, the record was discarded. The average main corrective movements in our accepted records is about 3°. This reduces the average displacement corresponding with our records to about 22°.

A large black screen was placed at 18 in. (45·75 cm.) in front of the subject, at one side of the camera. This screen was permanent and served all three experiments. It was pierced by three openings in the same horizontal line. Two openings for the exposure of objects were 8 in. (20·4 cm.) apart. The middle opening for the passage of the blue recording light was 5½ in. (14 cm.) from the left hand opening and was lost in the blind spot of the right eye when the centre of the left hand opening was fixed. This arrangement with respect to the blind spot was designed to lessen distraction by the light during the preliminary focusing of the camera. A movable black cardboard screen behind the permanent fixed screen carried a series of numerals. These were so oriented that as the screen fell, step by step, the numbers were successively exposed at the appropriate openings of the fixed screen. The movements of the screen were regulated by the operator. The signal to the operator was the reading of the exposed numerals by the subject. The amplitude of each movement of the screen was automatically regulated by an appropriate escapement.

Before each series of experiments two numbers were exposed respectively in the left and right hand opening, the middle one being closed. The patient was told that other numbers would appear in the same places, and that these were to be read aloud as rapidly as possible. Foreigners were encouraged to use the most familiar language. With the initial movement of the screen the middle opening was uncovered, allowing the subdued arc light to illuminate the subject's eye. Four groups of these movement-records were taken for each subject, making, when all the lines were legible, twenty-four movements. This number was unnecessarily large, since the mean variation is regularly less than half of the unit of measurement, but a tendency to coördinate winking just at the time of eye-movements together with head-movements and interrupted eye-movements made some of the individual records useless.

Since the illumination of the subject's eye was the condition of a photographic record, the simultaneous exposure and illumination were a mechanical guarantee that the beginning of the photographic record

was synchronous with the appearance of the stimulus to eye-movement. This arrangement gave the chief instrumental condition for the second and third series of experiments to determine the reaction-time of the ocular movements.

(c) *Results.*

Table I. shows the average duration of eye-movements of *cr.* 22 for nine normals, twenty-one maniacal-depressives, in both the maniacal and depressive phases, four cases of dementia præcox of the hebephrenic type, four epileptics, six paretics and one imbecile.

Under each form of insanity the data are arranged according to the severity of the disease. The most marked cases come first. Each case is described at length under the corresponding number in the Appendix, pp. 475 to 488. All time-values are given in $\frac{1}{1000}$ second.

TABLE I.

Normal.			
1	..	R. D.	... 59
2	...	A. ...	... 59
3	...	Wh.	... 61
4	...	Wr. ...	... 60
Female Nurses.			
9	...	Ll. ...	... 60
10	...	E. F.	... 54
Male Nurses.			
11	..	W. S.	.. 62
12	...	J. R.	... 60
Recovered Patient.			
17	...	M. D. (*c*)	... 60
Average			... 59
Low ...			... 54
High ...			... 62
M. V. ...			... 1·5

Mania.[1]			
Marked.			
13	...	S. S.	... 59
14	...	J. C.	... 44
15	...	W. B.	... 60
18	...	T. S.	... 51
19	...	J. G.	... 55
Average			... 54
Less Marked.			
31	...	L. K. (*b*)	... 60
21	...	A. H.	... 56
27	...	M. G. (*c-d*)	... 47
33	...	K. B. (*b*)	... 59
Average			... 55
Hypomania.			
22	...	G. ...	... 50
29	...	R. R. (*a*)	... 65
23	...	A. T.	... 76
20	...	S. K. (*c*)	... 51
24	...	P. B.	... 61
25	...	P. R.	... 70
Average			... 62
Low ...			...44, marked
High ...			...76, hypo.

Depression.[2]			
Marked.			
26	...	H. N. (*a-c*)	... 55
32	...	P. F. (*a*)	... 74
29	..	R. R.	... 77
Average			... 69
Less Marked.			
33	...	K. B.	... 72
Slight.			
34	...	T. B.	... 51
High ...			77—marked
Low ...			51—slight

[1] Maniacal phase of maniacal-depressive insanity.
[2] Depressed phase of maniacal-depressive insanity.

DEMENTIA PRÆCOX.

Marked.

36	...	A. R.	... 62
37	...	M. B.	.. 52

Moderate.

40	...	G. L.	... 60
41	...	M. F.	... 50

Slight.

42	...	B. M.	... 56
Average			 56

DEMENTIA PARALYTICA.

Marked.

43	...	D. D.	... 54
44	...	W. H.	.. 53
45	..	A. B.	... 60
47	...	A. S.	. 60
Average			... 57

Less Marked.

48	...	J. P. E.	... 54
49	...	J. A.	... 49
Average			 51

EPILEPTIC.

Moderate.

51	.	G. L.	. . 67
52	.	J. F.	.. 64
53	.	H. O.	... 67
54	..	M. B.	.. 80
Average			 69

IMBECILE.

57	...	R. H.	... 60

From the preceding table (I.) it is obvious that the velocity of the eye-movements of maniacal-depressive patients does not vary exactly with the degree of depression or of maniacal excitement which they present. On the other hand, it should be noted that there is some variation even among normal persons. In any fair evaluation of our data, then, one must allow at the outset for some individual variations, independent of all disease. The origin of these individual variations is at present a matter of conjecture. Earlier studies [6, 9] demonstrated that the differences between individuals are not absolutely constant for different angles of movement, or for the same angle of movement at different times. But these variations are relatively small, and are due, in part at least, to minor variations in the action of opposed and coöperating muscles which are not further analysed, and which may be grouped together for our purposes as chance variations. But after due allowance is made for these chance variations, the grossness of the variations in the insane and certain very obvious tendencies in different diseases and in different phases of the same disease indicate some causal inter-dependence with the disease itself.

While it would be injudicious to regard these tendencies as settled before our data have been materially increased, the marked variations of the extreme maniacal and the extreme depressive states may safely be regarded as characteristic. This appears not merely from Table I., but still more convincingly from the history of such cases as 26, H. N., p. 481; 29, R. R., p. 482; and 33, K. B., p. 484. So again both patients suffering from dementia præcox and dementia paralytica have abnormally rapid eye-movements, while the epileptics are notably long. The slow eye-movements of the extreme depressives and the quick

eye-movements of the extreme maniacal coincide with the general psychomotor disturbances as they appear in the familiar clinical picture of these psychoses. Quantitative evidence of abnormal quickness of maniacal movements has, however, hitherto been conspicuously lacking. On

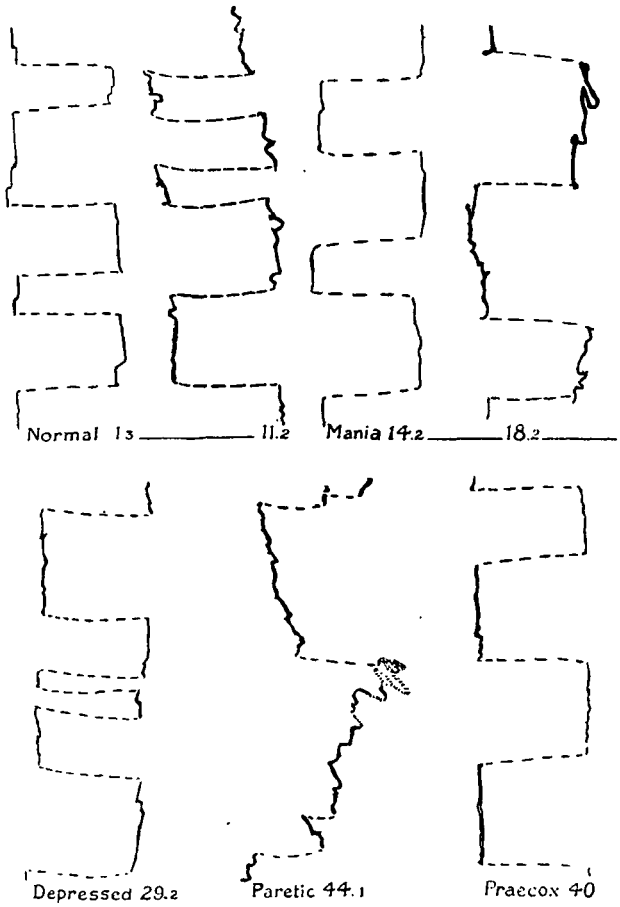

Plate I.

Plate I. is a reproduction of typical records of eye-movements. The records were projected by lantern and drawn from the projected image on a much enlarged scale. These drawings are here reproduced by process on a somewhat reduced scale. The resulting lines reproduce the original records very well, save that the dashes are relatively fainter grey in the records. The exact shape of each dash is not accurately reproduced. In all cases which are represented in Plate I. the photographic plate was moving so slowly that the dots run together in the vertical lines, appearing as dashes only during eye-movement. The dashes represent flashes of light succeeding each other every 0·01 second. The paretic line, No. 44·1, is an extreme case of head-movement and broken lines. The broken movements are typical, the head-movements less so.

the other hand, it is again congruent with the disease-picture that the eye-movements, which we have found to be rapid, are secondary automatic acts, not those that require conscious direction and control such as have hitherto been measured; and it certainly corresponds closely with our general knowledge of the diffusion of the sensory impulses and the interaction of the higher and lower nervous centres, that these secondary automatic movements should reach their extreme velocity when the interaction of the higher nervous centres is lessened.

The slowness of the eye-movements in the depressives and in the epileptics cannot be accounted for conversely by excessive interference of the higher centres. It seems rather to be the expression of a more widespread involvement resulting in a general inefficiency of the whole psychomotor system and including not only the higher centres, which appeared to be chiefly involved in mania, but also the lower centres, the simple reflexes, and the automatic acts.

Beside the mere differences of velocity in the eye-movements, there are certain characteristic tendencies in form and accuracy of eye-movement that our technique was not designed to measure, but which may be mentioned in passing. Along with the increased velocity in the maniacal eye-movements, there is a parallel tendency to abnormal overshoots such as were first described in normal persons by E. B. Huey [3]. Depressive eye-movements are more regular and symmetrical. The eye slides up into the new position as though against a gradually increasing resistance.

The eye-movements of the grossly demented show marked inaccuracies of fixation. Advanced dementia paralytica has curious inconsequential fixations, breaking the normal eye-movements at irregular points.

(2) Ocular Reaction-Time to New Peripheral Stimuli.

The second test concerned the simple reaction of the eye in responding to a peripheral stimulus. Like the first test, the second also depended on the regular and usually wholly unconscious habit of fixing a numeral or letter one is expected to read.

(A) *Experimental Conditions.*

The procedure was as follows: A figure 6 was exposed in the left hand slit of the permanent screen. The subject's attention was directed

to it with the instructions that other figures, which would appear at one side or other of the 6, must be read as rapidly as possible. With the final warning to look sharp, the 6 suddenly dropped out of sight and 1 in. (2·5 cm.) to the right or left there appeared a different numeral. The exposure apparatus resembled that used in the first series of experiments. A special exposure screen was prepared so as to expose one figure (6) at the centre of the left hand opening in the permanent screen when the exposure screen occupied its primary position. A series of numbers was pasted on pieces of black cardboard which could be slipped into place either to the right or left of the 6 and just so far above it as would bring them into view by one stroke of the escapement. It only required $\frac{1}{2}$ in. (1·25 cm.) movement of the exposure screen to carry the 6 out of sight and to expose the new number. The movement was so rapid that it seemed like an instantaneous change. Without the appearance of motion in any direction, the one seemed to disappear and the other was in place. The same movement of the exposure screen uncovered the arc light and began the photographic record. Simply counting the dashes of which the record was composed from the beginning of the record to the beginning of the eye-movements to fix the new number gave the reaction time of the eye in 0·01 second. A similar experiment is described more in detail in Dodge's "Experimental Study of Visual Fixation" [8]. Vocal reaction to printed matter or to isolated words, such as Dodge studied, seemed inexpedient in these tests on account of gross differences in education. Four ocular reactions were taken for each subject. Unfortunately, in some cases extreme head-movements made some of the records uncertain, while winking made other records useless. These two disturbances combined materially to reduce the number of available records.

The small number of reactions for any one individual is a serious limitation to the use of our data. If we had the work to do over again, we are agreed that we should venture to increase the number of simple reactions. Our reason for limiting the number in the present tests was the consciousness that we were dealing with subjects who were abnormally susceptible to fatigue of attention. To some of them even four tests of the same kind seemed many. For the sake of comparison, we ran through a series of ten reactions each with two more tractable cases. The results show that, in these two cases at least, the smaller number did no violence to the facts. In later discussions it will appear that minimal reactions and the general variability are quite as important as the rather meaningless averages.

(B) *Results.*

TABLE II.

Simple Ocular Reactions to Peripheral Stimuli.

(1) NORMAL.

1	...	R. D.	200
2	...	A. ...	200
3	...	Wh.	215
4	...	Wr.	210
Average			206
5	...	H. ...	192
6	...	T. ...	249
7	...	Wi.	140
8	...	C. ...	247
9	...	Ll. ...	223
10	...	E. F.	195
Average			208
11	...	W. S.	198
12	...	J. R.	225
Average			211
17	...	M. D.	222
Average			222
Average			209
High ...			249
Low ...			140

(2) MANIA.

Marked.

13	...	S. S.	205
14	...	J. C.	210
		,,	217
16	...	M. M.	225
17	...	M. D. (*a*)	250
18	...	T. S.	250
19	...	J. G.	210
20	...	S. K. (*b*)	229
Average			224

Less Marked.

31	...	L. K. (*c*)	260
21	...	A. H.	215
27	...	M. G. (*d*)	257
33	...	K. B. (*b*)	219
Average			238

HYPOMANIA.

22	...	G. ...	230
23	...	P. A.	225
20	...	S. K. (*c*)	202
24	...	P. B.	170
25	...	P. R.	230
Average			211
Average			224
High			260
Low Hypo. ...			170

(3) DEPRESSION.

Marked.

26	...	H. N. (*a*)	250
27	...	M. G.	295
29	...	R. R. (*c*)	173

Less Marked.

32	...	P. F.	379

Slight.

34	...	T. B.	293
17	...	M. D. (*b*)	204
Average			266
High			379
Low			173

(4) DEMENTIA PRÆCOX.

Marked.

36	...	A. R.	240
37	...	M. B.	185
38	...	R. B.	258
Average			228

Moderate.

39	...	A. Mcl.	276
41	...	M. F.	220

Slight.

42	...	B. M.	152
Average			222
High			276
Low			152

(5) DEMENTIA PARALYTICA.

Marked.

43	...	D. D.	370
44	...	W. H.	237
45	...	A. B.	225
47	...	A. S.	237
Average			267

Less Marked.

48	...	J. P. E.	190
49	...	J. A.	217
Average			203

Remission.

(50	...	F. A.	193)
Average			246
High			370
Low			190

(6) EPILEPTIC.

Moderate.

51	...	G. L.	298
52	...	J. F.	228
53	...	H. O.	195
54	...	M. B.	197
Average			229
High			298
Low			195

(c) *Discussion of Table II.*

The simple ocular reaction-time is long. According to our records the normal average lies above 200σ. In strict accuracy this average is undoubtedly too high, and should be reduced by a constant instrumental error of about fifteen. This error is involved in the form of the exposure of the peripheral stimulus. We have not tried to correct it, since it applies equally for all subjects, and our interest lies mainly in comparative rather than absolute time estimations. But after all corrections are made, these records agree with all the available data, and the simple ocular reaction-time is long.

One might *a priori* have expected that a reaction which is at once so common and apparently so necessary to the welfare of the individual in the conduct of life would be short. On the other hand, it must be noted that each ocular reaction to peripheral stimuli involves a considerable sensori-motor elaboration of the stimulus. The adequate reacting eye-movement is not only in a definite direction, but it is also of definite extent. The accuracy of the eye-movement does not now concern us, since we measure in reaction-time only the beginning of the reactive movement. But the beginning of every eye-movement is really only the initial phase of a movement of definite direction and extent. Before the eye starts, the elaboration of that particular motor impulse must be relatively complete. An accurate account of the correspondence between reaction-time and reaction-accuracy is a desideratum.

In a sense, every ocular reaction to a peripheral stimulus is not a simple reaction at all, but an individual adaptation to a change in the environment. In the past, such a reaction would have borne the misleading name of a "choice reaction." The length of the simple ocular reaction, then, is not an anomaly. It corresponds directly with the complex but automatic elaboration of the sensori-motor impulse.

Abnormal reactions may result from an indefinite number of changes within this complex sensori-motor process. This is at once the inspiration and the danger of every interpretation of complex reactions. In view of the possible complications, the relatively small mean variation for normal subjects points to a relatively stable normal oculo-motor systematization. It emphasizes at the same time the gross variations of the insane.

The small number of *per capita* records forces us to consider the reactions, as we were led to consider the velocity of movement by groups rather than by individuals. Furthermore, we will again limit

our generalizations to such gross variations as are inexplicable on the basis of chance variations.

The most conspicuous comparative feature of the results is the abnormally long reactions of the maniacal-depressive patients. Not only do they average long, but, with one exception, the average reactions of both the extreme and the less marked maniacal, and of all the depressed with one exception, are above the normal. These data are not novel. They agree with the reaction experiments of Franz.

In view of the unequivocal testimony of the averages, it is somewhat disappointing to note that there is no direct correspondence between the duration of the ocular reactions and the clinical judgment of the severity of the disease. It is hardly an accident that in spite of the high averages in cases of mania the most extreme maniacal excitement had the shortest ocular reaction; while the maniacal group, which averages the longest, is that of the less marked excitement. In view of the complication of the reaction-process and the number of unanalysed factors, we feel that any hypothesis of the effect of the disease on the reaction must be regarded as tentative. But on grounds which will appear most clearly in the discussion of the pursuit-reactions, we believe that the inconsequential reactions of maniacal excitement are due to opposed tendencies in the inter-relation of the superior and the secondary central systematizations.

(3) Ocular Pursuit-Reactions.

(A) *Theory.*

The third series of tests was a reaction experiment of unusual character. The simplest and, in the end, also the most complex ocular reaction with which we are acquainted is the pursuit-movement in reaction to a moving pendulum.

It is the simplest, in the sense that no new object of regard is furnished as stimulus for reaction. There is no change in the object of attention. An object is fixed, and the fixation lapses through the movement of the object fixed. The re-establishment of the lapsed fixation involves a form of ocular reaction such as occurs on an average several times a minute throughout the waking day, either because the object moves or because of involuntary displacement of the eyes by bodily movements. Pursuit-reactions, as we may call them, normally

involve a reaction-time slightly longer than the simple reactions to peripheral stimuli. At least one factor tending to lengthen the pursuit-reaction appears directly in the form of the stimulus. The stimulus to reaction is not given in the release of the pendulum, but only when, after release, the pendulum has moved some appreciable distance. The amount of movement that will constitute a stimulus to pursuit will depend on the training of the subject and the accuracy with which he maintains his fixations.

Paradoxical as it might at first seem, the total pursuit-reaction finally involves more extensive psychomotor elaboration than any other ocular reaction that we know how to produce. As is now well known (Dodge [7]), the true pursuit eye-movements are totally different in function and character from the rapid reaction-movements of the eyes by which peripheral objects of interest are fixated. The rapid movements are relatively constant in duration, and they constitute moments of practical blindness. The reason for this eye-movement blindness is still under discussion. There is no debate concerning the fact. The pursuit-movements, on the other hand, vary in angle-velocity with the angle-velocity of the moving object. The eyes move fast or slowly as the object moves fast or slowly. Moreover, the pursuit-movements are pre-eminently moments of relatively clear vision. It is because we wish to see an object clearly that we move the eyes as the object moves and keep its image on retinal areas of relatively clear vision. Furthermore, the psychomotor elaboration of the simple ocular reaction is fixed by the long-established habit of bringing excitations of the peripheral retina to areas of clear vision. The psychomotor elaboration of the pursuit-movements, on the other hand, is in practically each instance of pursuit an unique pyschomotor problem. The reaction to pursuit is fixed and habitual enough, but the velocity of the eye which shall correspond to the velocity of the object at the distance it chances to be can scarcely ever be a motor habit. To be a successful pursuit there must be an adaptation of the general pursuit tendency to the peculiar condition of each separate instance. Especially in the pendulum pursuit-movements are these conditions so various as to present, in each new case, practically unique conditions. Angle-velocity, apparent amplitude, and period of oscillation would all be alike only if pendulums of the same length swing through the same arc at the same distance from the eye of the observer. Yet unique as each case actually is, a normal eye will fall into an adequate pendulum pursuit-movement with surprising quickness and accuracy. In every normal individual the very first fixation after

the initial reaction to a moving pendulum has the characteristic true pursuit-slide, even though it usually corresponds in angle-velocity to the first part of the pendulum swing, and is consequently too slow. Let us emphasize the fact: for normal individuals, however inadequate the first attempt to fix the moving object may be, it always has the characteristics of a true pursuit-movement (*see* Plate 2, lines 1, 10, 11).

The return swing of a second pendulum is usually followed with precision, except at or near the middle of the arc of oscillation, when one or two short, sharp, rapid movements break the simple pendulum pursuits. The character of these pendulum pursuits scarcely alters, even after a large number of experiments under the same objective condition. Each new pursuit seems to be solved *de novo*, and the short-lived motor habits involved in every adequate pursuit seem to be lost when the pursuit is interrupted [8].

This ability to elaborate adequate pursuit-movements, *i.e.*, to adopt an adequate motor response to the peculiar situation presented by the rhythmic movements of an object, varies widely in mental disease. In some respects, the most marked variations are found in the pendulum pursuit-movements in dementia præcox, where a marked hesitation to fall into the swing of the pendulum was found even in the mildest cases. While this peculiarity is apparently not absolutely restricted to dementia præcox, it was found in other patients only where the disease-process has produced marked deterioration.

(B) *Experimental Conditions.*

The instrumental device for producing the pursuit-reaction and the subsequent pursuit-movements was a number attached to the bob of a second pendulum. The latter hung just in front of the fixed screen with its axis vertically above the middle point between the extreme left and right hand opening. Before the experiment the pendulum was held out of equilibrium in front of the left hand opening by a simple catch attached to a falling screen in the usual place behind the fixed screen. This falling screen was released by the operator, as in the other experiments, and the release of the screen simultaneously started the pendulum and opened the way for the recording beam of light. In every case the patient was previously shown how the pendulum moved and was then requested to watch the number closely, to keep his eyes on it, not to lose it, watch it, &c.

(c) *Results.*

TABLE III.

Ocular Reactions in Pursuit of a Moving Stimulus.

(1) NORMAL.

1	R. D.	198
2	A.	233
3	Wh.	243
4	Wr.	210
Average		221
5	H.	274
6	T.	284
7	Wi.	216
8	C.	225
9	Ll.	265
10	E. F.	285
Average		258
11	W. S.	235
12	J. R.	223
Average		229
17	M. D.	223
Average		239
High		285
Low		198

(2) MANIA.

Marked.

13	S. S.	190
14	J. C.	225
	,,	222
16	M. M.	343
18	T. S.	217
19	J. G.	225
20	S. K.	314
Average		248

Less Marked.

31	L. K. (*c*)	260
21	A. H.	217
27	M. G. (*c-d*)	305
33	K. B. (*b*)	255
Average		259

HYPOMANIA.

22	G.	210
29	R. R. (*a*)	220
23	P. A.	240
20	S. K. (*c*)	212
24	P. B.	155
25	P. R.	273
Average		218
Average		240
High (marked)		343
Low (Hypo.)		155

(3) DEPRESSION.

Marked.

27	M. G.	379
28	M. C.	255
29	R. R. (*c*)	230
30	L. W.	339
Average		301

Less Marked.

Slight.

34	T. B.	303
17	M. D. (*b*)	272
Average		287
Average		296
High		379
Low		230

(4) DEMENTIA PRÆCOX.

Marked.

36	A. R.	305
37	M. B.	195

Moderate.

39	A. McI.	207
40	G. L.	260
41	M. F.	215

Slight.

42	B. M.	275
Average		243
High		305
Low		195

(5) DEMENTIA PARALYTICA.

Marked.

43	D. D.	445
44	W. H.	240
45	A. B.	224
47	A. S.	267

Less Marked.

48	J. P. E.	227
Average		281
High		445
Low		224
Average excluding high		239

(6) EPILEPTIC.

Moderate.

51	G. L.	280
52	J. F.	222
53	H. O.	230
54	M. B.	221
Average		238

TABLE IV.

Table of Comparison of Averages.

Normal.			Depression.			Dementia Paralytica.		
Mvt.	Reactions	Pursuit-reactions	*Marked.*			*Marked.*		
59	209	239	Mvt.	Reactions	Pursuit reactions	Mvt.	Reactions	Pursuit reactions
Mania.			69	239	301	57	267	294
Marked.			*Less Marked and Slight.*			*Total.*		
54	224	248	61	295	287	55	246	281
Less marked.			Dementia Præcox.			Epileptic.		
55	238	259	*Moderate, Marked and Slight.*			69	229	238
Hypomania.			56	222	243			
62	211	218						

(D) *Discussion of Table III.*

In all classes except in moderate depression the pursuit-movement reaction averages longer than the simple ocular reaction. The differences between the two, however, are not constant. Even in the group of normal persons the differences are not constant. The variations, however, allow of some degree of classification. It must be remembered that the stimulus to pursuit-movement is not mechanically fixed as was the stimulus to a new peripheral stimulus. The movements of the pendulum operate as a stimulus to pursuit only when the lapsed fixation in some way makes itself felt through the indistinctness of the object. For the trained observer it operates almost immediately. For the less trained it operates only after the pendulum has moved some clearly appreciable distance. The mean difference between pendulum- and pursuit-reactions for normal observers under the conditions of our test was approximately 30σ. This average difference holds approximately the same for præcox and for the longer reactions of paresis. It does not hold for maniacal-depressives. But the individual variations are so great that the maniacal-depressive differences can scarcely be spoken of as characteristic. It does, however, constitute additional evidence of a high degree of disturbance of those complex superior central processes which are usually grouped under the general name of attention. Further evidence to the same effect comes from a consideration of minimal reactions, which are given in Table V.

TABLE V.

Table of Minimal Reactions.

NORMAL.			MANIA.			DEPRESSION.		
1	180	180	13	180	180	26	200	
2	180	200	14	180	180	27	279	244
3	206	230	16	186	257	28		228
4	200	200	17	205		29	170	210
5	166	260	18	210	200		216	227
6	230	273	19	160	210			
7	128	179	20	182	257	34	240	300
8	243	179		186	214	17 (*b*)	186	248
9	200	240					213	274
10	180	260	31	230	240	Average	215	246
11	140	200	21	190	210			
12	210	210	27	230	280			
17	220	190	33	190	190			
Average	191	216		210	230			
			22	210	200			
			23	210	200			
			20	190	200			
			24	150	140			
			25	210	220			
				194	192			
			Average	195	211			

DEMENTIA PRÆCOX.			DEMENTIA PARALYTICA.			EPILEPTIC.		
36	200	260	43	350	290	51	270	250
37	180	190	44	220	200	52	200	200
38	248		45	210	210	53	190	210
			47	230	240	54	170	200
39	260	167				Average	207	215
40		240	48	170	210			
41	200	180	49	180				
42	150	230	50	180				
Average	206	211	Average	220	230			

Discussion of the Table of Minimal Reactions (Table V.).

In some respects the minimal reactions for any well-established type of reaction is more instructive than the average reaction. The minimal reaction shows the reflex systematization in its highest state of efficiency. The mean reaction indicates the average state of efficiency. The two differ from one another by the mean value of all those disturbing elements that may complicate the reaction-process. It seems to the writers a very significant fact that the average minimal reaction of extreme maniacal excitement is below the average minimum of normal subjects. It is not much below the normal, but it is not above it as the total average is. Moreover, the mean variation of the minimal reactions

is approximately the same as the mean variations of the averages. This consistent uniformity is not accidental. In connexion with the adequate pursuit-reactions it seems to the writers to constitute unequivocal evidence that the oculo-motor systematization is not seriously disordered in acute mania. The large mean value of disturbing elements constitutes the final point that we have to offer in the cumulative experimental evidence that extreme mania involves a marked disturbance of the controls normally exercised by the superior central systematizations.

This seems to the writers to coincide closely with the general clinical picture of marked mania. The motor organization even for complex acts is not lost. The incapacity for regular employment is flagrantly due to gross disturbances of the normal controls within the higher systematizations. Tentatively, at least, we may picture this in terms of an inhibition of the free interaction of the various factors in the normal complex superior organization.

Provided there is some intrinsic retardation of the intermediate systematizations, like the simple oculo-motor reflexes, we should expect to find the total evidences of maniacal excitement less marked. In such cases we should expect the minimal reactions to be long as well as the average reactions. This is actually the case in less marked mania. It looks as though the inhibitory processes involved in the disease were affecting lower centres. The climax of this downward progression seems to be reached when, in *extreme depression*, the resistance to neural interaction involves the simplest reflexes.

In contrast to the differential increase of resistance to neural activity as found in the maniacal-depressives, our experimental data from the demented point to a general disorganization of the central systematizations.

In dementia paralytica the entire nervous system is involved in this disorganization, as is shown by the marked retardation, and the inefficiency of the simplest, as well as of the higher reflexes (patellar, pupillary, and cerebellar).

In præcox the disorganizations seem to be primarily limited to the superior systematizations. This is shown negatively by the rapid eye-movements, normal oculo-motor reactions, and positively by the difficulty of adopting adequate reactions to new conditions of the environment, as in the pursuit-movements. This latter peculiarity of præcox patients has a practical as well as a theoretical interest.

Practically, it is an important differentiating symptom between moderate maniacal excitement and developing præcox, *i.e.*, between two

psychoses whose differential diagnosis is of the utmost importance and often of the utmost difficulty. Unfortunately the faultiness of the pursuit is not easily detected by direct observation. Photographic registration, although remarkably simple as a scientific technique, is rather too expensive in time and apparatus for regular professional use. If the matter prove worth while, a simplified recording apparatus is probably the only safe and practicable solution. It would seem strange,

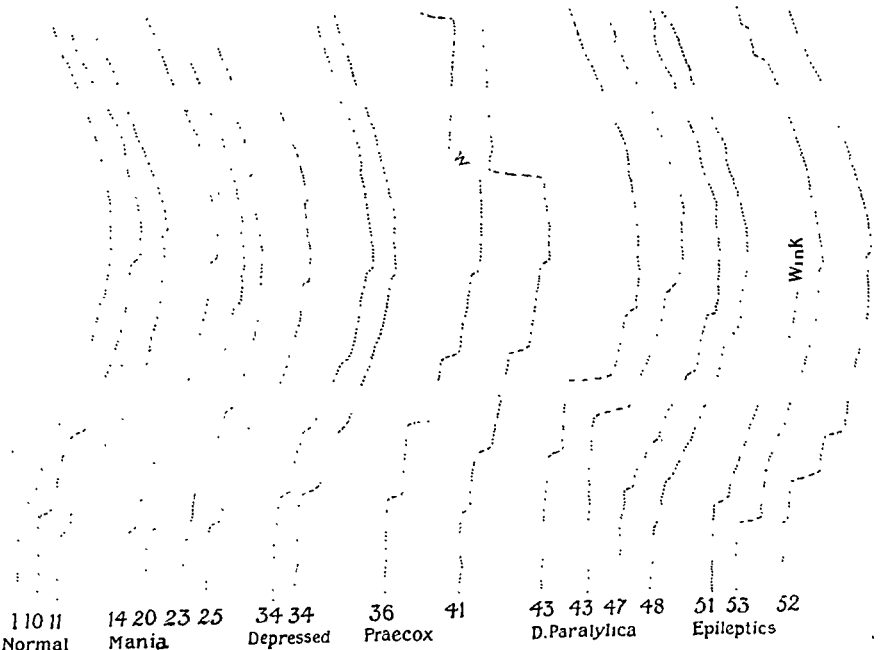

Plate II

Plate II. is reproduced from drawings of typical pursuit-reaction records. It shows most of the typical variations of the visual pursuits so far as they were not complicated by gross head-movements. The lines accurately reproduce only the general configuration of the pursuit.

Each line, reading from the bottom up, represents one complete pursuit-swing corresponding to a double oscillation of the second pendulum. Since the release of the pendulum and the beginning of the record are synchronous, the straight line at the beginning of each record gives the reaction-time. The reaction begins with a sharp horizontal movement to the right. This is followed by the slow pursuit swing, which is more or less adequate according to the nature of the disease. The præcox pursuits, Nos. 36 and 41, are typical. In mild cases the hesitation to adopt the pursuit-swing is less pronounced, but it is regularly shown by straight lines somewhere in the pursuit. The maniacal pursuit shows a tendency to get ahead of the pendulum (*see* upper part of lines 14, 23 and 25). This tendency sometimes appears in the first positive acceleration of the pendulum in maniacal cases. It is not entirely absent from normal pursuits or from moderate depression. In the latter cases, however, it is very rare. Other modifications of the pursuit are suggestive, but at present they permit no generalized statement.

The double breaks in each record are occasioned by the swinging of the pendulum through the recording beam of light.

however, if similar phenomena cannot be found in other forms of reaction which are more accessible to direct observation.

The theoretical bearing of the inadequate ocular pursuit-movements of præcox we have already mentioned. It was not overlooked by us that the simplest explanation of the phenomenon would be to coördinate it with those processes which are ordinarily grouped under the head of faulty attention. This explanation seems to us untenable on the following grounds:—

(1) Equally grave defects of "attention" exist in maniacal excitement without parallel difficulty of pursuit.

(2) The reaction-times do not indicate gross defects of "attention" in moderate præcox.

(3) Reasonable "attention" and effort at pursuit are both clearly indicated in the number and character of the short corrective movements.

Finally, the phenomenon seems to connect itself naturally with certain characteristic clinical observations of præcox as one manifestation of the patient's inability to adapt himself to new and unusual requirements of his environment. Put technically, it is the patient's inability to adopt adequate short-lived habits in response to a new recurrent situation. There is some clinical evidence that this motor phenomenon rests on a basis of faulty elaboration of the perceptual data. Our experiments indicate that the intellectual defect is a matter of inadequate appreciation rather than a matter of attention.

The writers take this opportunity to express to Dr. H. S. Noble, Superintendent of the Connecticut Hospital for the Insane, their cordial appreciation of his sympathetic interest and encouragement which made this series of experiments possible.

The Appendix contains a brief account of each case by Dr. Diefendorf, together with all the unambiguous comparative data from the photographic records.

APPENDIX.

NORMALS.

	Mvt.	Simp. R.	Pend. R.
1. R. D., practised	No. 19	200	210
	Av. 59	220	190
		180	180
			210
		200	
			198

		Mvt.	Simp. R.	Pend. R.
2.	A., student	No. 13	... 180	... 200
		Av. 59	... 220	... 240
				260
			200	
				233
3.	Wh., student	No. 7	... 210	... 230
		Av. 61	230	... 256
			206	
				243
			215	
4.	Wr., student	No. 8	... 230	... 220
		Av. 60	200	... 200
			210	... 210
			200	
				210
			210	

5 *to* 10.—*Female Nurses.*

5.	H., aged 64	Series	... 230	... 292
		I. No	166	... 273
		Mvts.	204	... 260
			166	... 273
			192	274
6.	T., aged 65	Series	... 260	... 293
		I. No	230	... 273
		Mvts.	256	... 287
			249	284
7.	Wi., aged 67	Series	... 153	... 199
		I. No	128	... 205
		Mvts.	133	... 282
			148	... 179
			140	216
8.	C., aged 69	Series	... 251	... 230
		I. No	243	... 179
		Mvts.		235
			247	256
				225

		Mvt.	Simp. R.	Pend. R.
9.	Ll., aged 45	No. 26	260	250
		Av. 60	210	320
			200	250
			——	240
			223	——
				265
10.	E. F., aged 46	No. 22	180	260
		Av. 54	216	310
			——	——
			195	285
	Male Nurses.			
11.	W. S., aged 38	No. 24	260	270
		Av. 62	140	220
			210	200
			180	250
			——	——
			198	235
12.	J. R., aged 39	No. 7	220	240
		Av. 60	260	210
			210	220
			210	——
			——	223
			225	
	Recovered Patient.			
See 17, M. D. (*c*) for full record		Av. 60	222	223

MANIACAL-DEPRESSIVE INSANITY.

Maniacal Phase, Marked.

13.	S. S., F.,[1] aged 49. Second attack of two months duration. A. T.[2]—Extreme pressure, with impulsiveness. Marked spontaneity, flight of ideas, distractibility, and irritability. I. A.[3]—Held with great difficulty. Many readjustments necessary. Shouted. Commented. Added figures.	No. 8	180	200
		Av. 59	230	180
			——	——
			205	190

[1] The letters F. and M. after the patient's initials refer to the patient's sex.
[2] A. T. gives the patient's condition *at the time* of examination.
[3] I. A. gives the patient's behaviour *in the apparatus*.

	Mvt.	Simp. R.	Pend. R.
14. J. C., M., aged 51. Numerous attacks of maniacal phase. Present attack of two months duration. A. T.—Marked pressure. Spontaneity. Flight of ideas. Elation. Distractibility. Marked impulsiveness and destructiveness. Person smeared and naked on ward. I. A.—Surprisingly tractable and helpful. Shouted responses.		(*a*)	
	No. 16	180	215
	Av. 45	240	240
		——	220
		210	——
			225
		(*b*)	
	No. 8	200	180
	Av. 43	220	240
(*b*) Second plate several days later. Same conditions.		230	240
		——	230
		217	——
			222
15. W. B., M., aged 30. Third attack of eight months duration. A. T.—Extreme pressure. Marked productivity and flight of ideas, distractibility, emotional irritability and elation. I. A.—Tractable, loquacious, distractible. Sluggish. Eyelids sagged. No legible reactions.	No. 5		
	Av. 60		
16. M. M., F., aged 38. Second attack of two months duration. First of five months duration. Lucid interval of seventeen months. A. T.—Marked excitement. Extreme pressure. Flight of ideas. Irritable. Violent. Destructive. Untidy. Partial orientation. I. A.—Remarkable self-control. Obvious suppressed excitement. Voice loud. Many comments.	Series	186	(695)
	I. No	264	335
	Mvts.	——	257
		225	437
			——
			343
17. M. D., F., aged 26. Five years duration. For the last three years regular alternation from depressive to maniacal phase without lucid intervals. A. T.—Marked pressure. Elation. Distractibility. Flight of ideas. Noisy. Irritable moods. Tore clothing. No deterioration. I. A.—Tractable. Complained that pendulum was blurred.		(*a*)	
	Series	290	
	I. No	254	
	Mvts.	205	
		——	
		250	

	Mvt.	Simp. R.	Pend. R.
(*b*) Same at second experiment. Just passed to depressive state. Slight retardation without despondency. Exaggerated feeling of incapacity.		(*b*)	
		186 ...	309
		222 ...	263
		——	273
		204	248
			273
			268
			——
		(*c*)	272
(*c*) Same five months later. Normal.	No. 19 ...	225 ...	(300)
	Av. 60	220 ...	210
		220 ...	270
		——	190
		222	——
			223
18. T. S., M., aged 67. Maniacal phase of three months duration immediately preceded by depressive phase of fourteen months duration. A. T.—Considerable pressure of activity. Busyness. Constant speech. Flight of ideas. Increased irritability, with elation. Distractibility. I. A.—Talked constantly. Responded correctly and rapidly.	No. 11 ...	270 ...	250
	Av. 51	270 ...	200
		210 ...	200
		——	——
		250	217
19. J. G., F., aged 52. Recurrent attacks for many years, both maniacal and depressive. A. T.—Maniacal phase of two months duration. Considerable pressure. Great productivity. Distractibility. Increased irritability predominating elation. I. A.—Loud responses. Movements seemed deliberate. Kept in position with difficulty. At times refuses to open eyes.	No. 8 ...	190 ...	210
	Av. 54	160 ...	240
		200	——
	No. 13 ...	290	225
	Av. 56	——	
		210	
		(*b*)	
		No. 10	
		Av. 204	
		M. V. 11	
(*b*) Same. Series of ten reactions.			
20. S. K., M., aged 40. Eight years duration. For last three passed immediately from one maniacal state to another, average six months duration. No deterioration. A. T.—Marked excitement. Pressure of activity. Flight of ideas and distractibility. Elation and impulsive outbreaks. Consciousness clear. I. A.—(*a*) Violent laughter. Intolerant of assistance.		(*a*)	
	Illegible.	Too much head-movement.	
		(*b*)	
	Series ...	275 ...	342
	I. No	261 ...	347
	Mvts.	199 ...	308
		182 ...	257
		——	——
		229	314

		Mvt.	Simp. R.	Pend. R.
(*b*)	Less intractable.			
(*c*)	Same five months later. Somewhat improved. Hypomania. Tractable. Responds rapidly. Attends well.	No. 19 Av. 51	(*c*) 210 ... 200 190 ... 200 210 .. 230 200 .. 220 202	212

Maniacal Phase, Less Marked.

31.	L. K., F., aged 63. Maniacal excitement after moderate depression. *See* description under depressive phase, less marked, 31 (*b*) and (*c*).	No. 25 Av. 60	No. 4 ... 260	No. 4 260
21.	A. H., M., aged 73. Third attack of six months duration. A. T.—Irritability, with predominating elation. Pressure of activity. Flight of ideas. Distractibility. I. A.—Very tractable. Responses correct and rapid. No evident disturbance of attention.	No. 5 Av. 56	(265) ... 215 ... 240 ... 190 ... 215	220 210 220 W. 217
27.	M. G., F., aged 60. Moderate mania after extreme depression. *See* description under depressive phase, marked, 27 (*c*) and (*d*).	No. 22 Av. 47	No. 3 ... 257	No. 6 305
33.	K. B., F., aged 44. Moderate mania after moderate depression. *See* description under depressive phase, less marked, 33 (*b*).	No. 14 Av. 59	No. 4 ... 219	No. 4 255

HYPOMANIA.

22.	G., M., aged 18. First attack eighteen months duration. A. T.—Slight pressure. Mischievous and boisterous. Considerable spontaneity of speech with rambling thought. Distractibility. Irritability. I. A.—Excellent behaviour. Held himself.	Av. 50	220 ... 230 ... 260 ... 210 ... 230	220 210 220 200 210 200 210
29.	R. R., F., aged 14. Hypomania preceding marked depression. For description *see* under depressive phase, marked, 29 (*a*).	Av. 65		Av. 220

	Mvt.	Simp. R.	Pend. R.
23. P. A., F., aged 59. Many attacks, mostly maniacal, for thirty-three years. A. T.—Just emerging from maniacal phase of two weeks duration. Slight irritability, distractibility and loquacity. I. A.—Quite tractable. Commented on apparatus and added figures.	No. 19 Av. 76	230 240 220 210 225	260 250 200 250 240
20. S. K., M., aged 40. Hypomania following pronounced maniacal state. For description *see* under maniacal phase, marked, 20 (*c*).	No. 19 Av. 51	202	212
24. P. B., M., aged 27. Second attack of two weeks duration. A. T.—Moderate busyness. Slight elation. Flight of ideas, spontaneous speech. I. A.—Excellent behaviour. Good interest.	No. 6 Av. 61	150 190 170	140 170 155
25. P. R., M., aged 20. Second attack of three weeks duration. A. T.—Moderate irritability and impulsiveness. I. A.—At first irritable, then more tractable and pleasant.	No. 10 Av. 70	(390) 240 240 210 230	285 315 220 273

MANIACAL-DEPRESSIVE INSANITY.

Depressive Phase, Marked..

26.—H. N., F., aged 34. Second attack. Two months duration. Three days before test patient suddenly changed overnight from active maniacal state to stuporous state. A. T.—Profound retardation of thought, attention and action. Complete disorientation. Fogged consciousness. Feeling of inadequacy. I. A.—Somewhat resistant. Slow, partially inaudible responses. Better at end.		(*a*)	
	No. 9 Av. 53	235 275 250	Pursuit on second swing.
		(*b*)	
	No. 7 Av. 55	240 200 200 250 222	No pursuit.
(*b*) Same next day. Condition unchanged. Responded only after urging.			
(*c*) Same next day. Slight improvement. Series of eight reactions as test.		(*c*)	
	No. 11 Av. 56	No. 8 Av. 206 M. V. 20	No pursuit.

	Mvt.	Simp. R.	Pend. R.
27. M. G., F., aged 60. For years alternating attacks of maniacal-depressive insanity without lucid intervals. No evident deterioration. A. T.—Extreme despondency. Marked retardation. No voluntary speech or activity. Almost inaudible replies. Marked self-accusation. Without illusions or hallucinations. Perfect orientation. I. A.—Slow faint responses.			408 369 244 494 — 379
		(*b*) 289 279 318 —	
(*b*) Same several days later. Retardation less marked. Occasional remark. Entrance and exit from room now without prodding. Reactions apparently good.		295 (*c*)	
(*c*) Same five months later. Moderate mania with slight pressure. Moderate distractibility and flight of ideas. I. A.—Tractable. Poor attention.	No. 8 Av. 46		300 280 290 — 290
(*d*) Same next day. Still more distractible owing to presence of visitors.		(*d*)	
	No. 14	(420)	350
	Av. 48	280	320
		260	300
		230	—
		—	323
		257	
28. M.C., F., aged 45. Third attack of maniacal-depressive insanity, depressive phase of nine months duration. No hallucinations, illusions or deterioration. A. T.—Marked retardation evident in attention, train of thought and volition. No voluntary speech. Meagre and slow responses. Various delusions of self-accusation. Emotionally depressed and apprehensive.			228 291 246 — 255
29. R. R., F., aged 14. Numerous attacks of maniacal phase and one of depressive within last twelve months. A. T.—(*a*) Hypomania. Moderate elation, productivity, flight of ideas and distractibility. Busyness. I. A.—Tractable. Excellent reactions.		(*a*)	
	No. 12		240
	Av. 65		190
			230
			—
			220

	Mvt.	Simp. R.	Pend. R.
		(*b*)	
(*c*) Same six days later. Marked depressive stage. Profound despondency. Extreme retardation. No voluntary speech. Sluggish movement. I. A.—Timid. Shrinking from nose-piece. Responses slow, almost inaudible, and only after urging.	No. 26	230	240
	Av. 70	170	240
		170	210
		180	200
		188	222
		(*c*)	
	No. 20	170	260
	Av. 77	180	230
		170	210
		173	220
			230
30. L. W., F., aged 57. For fifteen years recurrent attacks of maniacal-depressive insanity without lucid intervals. A. T.—Depressive phase of two years duration. Pronounced retardation of thought, attention and volition. Very little spontaneous speech or activity. Deep emotional depression, without delusions. Good orientation. Some deterioration in memory and judgment. General indifference.			300
			350
			369
			339

Depressive Phase, Less Marked.

		(*a*)	
31. L. K., F., aged 63. For many years alternating attacks of maniacal and depressive phases without intermissions. A. T.—Emerging from depressive attack of several months duration. Considerable retardation of thought, volition, and attention. Little voluntary speech. Low tones and slow responses were explained by patient as results of "difficulty of thought." Sad and wished to die. No hallucinations or delusions. Good orientation. Clear consciousness. I. A.—Tractable.	Series I. No Mvts.	324	302
		324	302
		(*b*)	
	No. 13		290
	Av. 60		260
(*b*) Same five months later. Maniacal excitement. Busyness. Volubility. Pronounced elation. Distractibility. I. A.—Tractable. Good attention.			240
			250
			260

	Mvt.	Simp. R.	Pend. R.
(*c*) Same several days later. Still more maniacal. Great pressure and productivity. Great distractibility. Difficulty in reading figures. Many mistakes.	No. 12 Av. 60	(*c*) 280 290 240 230 260	
32. P. F., M., aged 28. For four years numerous attacks of maniacal-depressive insanity. At first alternate depression and elation, of several months duration, with brief lucid intervals. During past year attacks were shorter, more severe and without lucid intervals. A. T.—Marked despondency with retardation. Dejected and lachrymose. Moved from seat in ward only occasionally, after insistent prodding. Meagre replies. Complained of numbness, &c. No hallucinations or delusions. Good orientation. No deterioration.		(*a*) 398 360 379	None taken.
	No. 7 Av. 69	(*b*) 239 155 253 216	Not clear.
(*b*) Same several days later. Mild maniacal excitement of two days duration. Mild pressure of activity, talkativeness and flight of ideas, and distractibility. Elated. Talks of future work. Disoriented as to time. Same several days later. Another depressive phase. Refused to enter apparatus.	No. 11 Av. 74	(*c*) Refused to react.	
(*c*) Same five months later. Profound retardation. Slight elation and occasional smiles. I. A.—Tractable. Good attention. Retardation too pronounced to read figures.			
33. K. B., F., aged 44. Two months duration. A. T.—Pronounced retardation of thought, attention, and volition. Self-accusatory delusions. Considerable apprehensiveness. I. A.—Tractable. Poor attention. Needed constant prodding. "Felt sleepy."		(*a*) None.	None.
	No. 5 Av. 72		
	No. 14 Av. 59	(*b*) 225 250 190 210	240 190 290 300
(*b*) Same two days later. Moderate maniacal phase. Better attention. Responses more audible and rapid.		219	255

Depressive Phase, Slight.

		Mvt.	Simp. R.	Pend. R.
34.	T. B., F., aged 29. In third attack of maniacal-depressive insanity. First at 21 was depressive. Second at 28 was maniacal. Present attack of six months duration is mildly depressive. No deterioration. A. T.—Perfect orientation. Retardation evident in train of thought and general lack of activity. Little voluntary speech unless questioned. Speech slow and low. Profoundly dejected and somewhat lachrymose. Some self-accusation. Otherwise no delusions.	No. 13	250	300
		Av. 51	240	310
			390	300
			293	303
17.	M. D. For full description *see* under maniacal phase, marked, 17 (*b*).		204	272

DEMENTIA PRÆCOX.

Hebephrenic Marked Dementia.

36.	A. R., aged 36. Thirteen years duration. A. T.—Extreme apathy. Indolence. Paralysis of thought. Silly laughter. Blunted attention. Faulty judgment. I. A.—Poor attention. Eyes apparently wandered everywhere. In only one of the four reactions were the figures read.	No. 10	280	260
		Av. 62	240	350
			200	
				305
			240	
37.	M. B., F., aged 32. Seven years duration. A. T.—Desultoriness. Paralysis of thought. Residuals of former erotic delusions. Occasional hallucinations of hearing. Pronounced defects of memory. I. A. — Apprehensive. Marked head-movements. Faulty attention. Figures were apparently read rapidly.	No. 12	190	200
		Av. 52	180	190
			185	195
38.	R. B., F., aged 26. Six years duration. Marked impairment of memory and intellect. Marked emotional deterioration. Extreme paralysis of thought. Complete disorientation. Inability to care for herself. I. A.—Attention poor. Jerky head-movements. Shut her eyes and looked languidly about. Speech reactions slow or wanting. Records largely illegible owing to head-movements.	Series I. No Mvts.	268	
			248	
			258	

Moderate Dementia.

		Mvt.	Simp. R.	Pend. R.
39.	A. McI., F., aged 19. Twenty-one months duration. A. T.—Moderate dementia. Residuals of former grandiose delusions. Moderate defects of memory, paralysis of thought and will. Emotional deterioration. Oriented and without hallucinations. I. A.—Adapted herself readily to the apparatus and seemed to respond easily. Slight apparent retardation.		(415) ... 292 ... 260 ... 276	246 ... 167 ... 207
40.	G. L., M., aged 30. Several months duration. From onset moderate despondency with delusions of self-accusation, reference and persecution. Occasional hallucinations of hearing. I. A.—Excellent behaviour. Good interest and attention.	No. 13 Av. 60	(420)	290 260 240 250 260
41.	M. F., M., aged 31. One year's duration. A. T.—Constant aural hallucinations. Consciousness clear. Orientation perfect. Slight defects of memory. Some paralysis of thought. Persecutory and somatic delusions. Diminished emotional and volitional activity.	No. 13 Av. 50	210 ... 200 ... 250 ... 220	250 ... 210 ... 180 ... 220 215

Slight Dementia.

42.	B. M., M., aged 26. Twelve months duration. A. T.—Slight emotional deterioration. Laziness. Occasional silly laughter. In all other respects apparently normal and ready for discharge. I. A.—Splendid behaviour. Answered with unusual promptness, and seemed interested.	No. 17 Av. 56	150 ... 160 ... 150 ... 150 ... 152	Straight. ... 230 ... 320 ... Wink. 275

DEMENTIA PARALYTICA.

Marked Dementia.

43.	D. D., M., aged 42. Two years duration. A. T.—Advanced physical signs. Still able to care for himself. Totally incapable of simplest labour. *Note.*—The first two pursuits contain one straight line each.	No. 11 Av. 54	370 ... 390 ... 350 ... 370	290 ... 420 ... 550 ... 520 445

	Mvt.	Simp. R.	Pend. R.
44. W. H., M., aged 48. A. T.—Extreme dementia. Pronounced physical signs. Patient died one week later in apoplectic seizure. I. A.—Held without difficulty. Responses apparently slow.	No. 7 Av. 53	220 270 220 237	280 240 200 240
45. A. B., M., aged 43. Three years duration. A. T.—Advanced dementia with marked physical signs. I. A.—Held position with difficulty.	No. 2 Av. 60	220 262 210 210 225	241 210 220 224
47. A. S., M., aged 42. Three years duration. A. T. — Advanced dementia. Numerous physical signs. Euphoria. Still able to care for self. I. A.—Tractable. Apparently excellent attention.	No. 20 Av. 60	(370) 230 240 240 237	240 310 250 270 267
Less Marked Dementia.			
48. J. P. E., M., aged 60. Eleven months duration. A. T.—Considerable dementia. Marked physical signs. Defective memory. Disorientation. Paralysis of thought. Feeling of well-being. Some apathy. Grandiose delusions. I. A.—Tractable. Apparently good attention. Responses unusually rapid.	No. 5 Av. 54	210 170 190	210 260 210 227
49. J. A., F., aged 44. One year's duration. Demented type. A. T.—Fairly pronounced dementia with severe physical signs. I. A.—Difficult to hold in position. Indifferent and poor attention. (*b*) More interested and tractable.	No. 18 Av. 49	(*b*) 200 260 180 230 217	No pursuit.
REMISSION.			
50. F. A., M., aged 43. Twelve years duration. Marked remission. Some emotional deterioration. Slightly faulty judgment. Some elation. Some spontaneity of thought. I. A.—Conduct excellent. Helpful. Read figures quickly and correctly. Marked head-movements interfered with tests 1 and 2.	Head-movements.	180 200 200 193	Head-movements.

EPILEPTICS.

All Moderate.

		Mvt.	Simp. R.	Pend. R.
51.	G. L., M., aged 57. Three years duration. A. T.—Moderate dementia. Faulty memory. Impaired judgment. Delusions of infidelity. Irritability. Periodic ill-humour and violence. I. A.—Splendid behaviour. Good interest and attention.	No. 19	330	290
		Av. 67	300	250
			290	290
			270	290
			298	280
52.	J. F., aged 56. Twenty-six years duration. Within last few years moderate deterioration. Faulty impressibility of memory, and faulty judgment. Increased irritability. I. A.—Good interest and apparently normal reactions.	No. 9	200	210
		Av. 64	210	255
			260	200
			240	
			228	222
53.	H. O., M., aged 37. Epileptic convulsions at $2\frac{1}{2}$ years. Mental deterioration developed at 34. A. T.—Slight defects of judgment. Increased irritability. Periodic gloominess and stubbornness. Slight defects of memory. I. A.—Tractable. Good attention.	No. 9	190	240
		Av. 67	200	240
				210
			195	
				230
54.	M. B., F., aged 38. Twenty-one years duration. Slight deterioration. A. T.—Increased irritability. Slight defects of memory. Variable moods. I. A.—Splendid behaviour. Good interest. Apparently rapid reactions.	No. 8	170	240
		Av. 80	200	220
			220	225
				200
			197	
				221

IMBECILES.

Five cases of moderate imbecility gave only very scanty material. There were, however, no cases of the præcox pursuit.

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