ON THE USE OF MENTAL TESTS FOR THE MEASUREMENT OF DISABILITY AFTER HEAD INJURY

WITH A COMPARISON BETWEEN THE RESULTS OF THESE TESTS IN PATIENTS AFTER HEAD INJURY AND PSYCHONEUROTICS

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WHERE knowledge of a medical condition is incomplete, there is a danger that the results of ancillary aids, especially when expressed in numerical terms, may acquire an unwarranted appearance of infallibility. The post-concussional state provides a good example of this tendency, for, while the core of the problem remains obscure, the results of investigations which have only presumptive relationships with the essential condition are liable to be accepted as direct, quantitative indicators of the total disablement. Radiology, psychometry, and electro-encephalography are all open to criticism on this score. For example, though the significance of skull fracture is still uncertain, *x*-ray examination is commonly regarded as essential after head injury. It is perhaps fortunate that only the initiated can interpret an electro-encephalogram tracing; but the result of a psychometric test, usually expressed as a percentage deficit, is apt to stand out, in a case record, as the one fact on which the patient's condition can be assessed. There is no doubt that changes in personality occur after head injury in some cases, and, with them, what appear to be defects of intellectual function, usually at the higher levels. But it is almost certainly incorrect to suppose that intelligence tests measure only high-level intellectual activity; in fact they take a cross sectional sample of conscious mentation, in which affective elements play a most important part. Even in normal persons it is necessary to take account of such factors when a test score is interpreted; their presence in pathological cerebral states introduces, in the opinion of some writers, "an infinite source of error" (Goldstein, 1942a). Nevertheless, mental tests are widely used to measure quantitative intellectual impairment after head injury, and it was to investigate the usefulness of this method of examination that the experiment on which this paper is based was planned.

The basic principles of what is now called differential testing have long been known and were noted by the early workers on aphasia (Hughlings Jackson, 1878) but Babcock (1930) appears to have been the first to apply these principles in the form of mental tests. The theory and technique of the method are fully explained by Brody (1944b), who also gives a review of the literature. It was also observed by Hughlings Jackson (1868) and Henry Head (1920, 1923) that cerebral damage had an apparently specific effect on the ability of some patients to deal with abstract problems. This disability has been more fully explored by the Gestalt psychologists. Goldstein (1942b) regards it as of the greatest importance in understanding the difficulties of the head injury patient, and Weigl (1927), among others, has devised a test to reveal it.

In order to investigate the usefulness of mental tests for the measurement of disability after head injury, one hundred patients who gave a history of a head injury were examined and given a series of tests. Their performance was compared with that of fifty normal persons and fifty psychoneurotics. The last were included because of the similarity between the symptoms of some types of neurotic and some post-concussional patients, and to examine the possibility that neurosis alone might be the cause of the failure in these tests reported by other writers.

Material and Methods

The head injury series was made up of one hundred Naval Officers and ratings who had been admitted to a naval hospital with the history of an injury to the head and a diagnosis of "post-concussional state". These patients were a consecutive series, the only conditions for inclusion being the clear history of one or more head injuries and the patient's ability to co-operate in the tests. In a number of cases the patients were referred to

the writer for a psychiatric opinion because they complained of symptoms for which there appeared to be no adequate physical signs; they were, therefore, far from being a random sample of head injuries, but there is no reason to doubt that they were a representative sample of the post-concussional state. It was not considered justifiable to exclude those who had been sent for examination because they were thought to be showing psychoneurotic symptoms, for it is in the assessment of this large group that the information which might be given by mental tests is most needed.

All these men were serving members of the Royal Navy, in no case were cerebral arteriosclerosis, alcoholism, or any other organic medical condition considered to be a contributary factor in their illness. The type of injury ranged from kicks at football to gunshot wounds. Service regulations ruled out the compensation issues, so common in industrial and road accidents, because any injury received on duty, which includes organized recreation or enemy action, is regarded as attributable unless it is due to misconduct or neglect on the part of the patient. In this series, in no case in which the injury was sustained off duty was there any question of compensation from outside the Service at the time the patient was examined. The series includes five "punchdrunks", three of whom, in addition to their boxing injuries, had suffered blows on the head leading to unconsciousness. No case of simple blast concussion was included, although some patients were undoubtedly exposed to blast in addition to direct trauma at the time of their injury.

Table I records the principal clinical characteristics of the head injury series.

TABLE I

A. Number showing abnormalities in the central nervous system	37
Type of abnormality:	
Focal cerebral palsies	21
Paresis of limbs	9
Post-traumatic epilepsy	4
Post-traumatic diabetes insipidus	2
Post-traumatic Parkinsonism	1
B. Length of post-traumatic amnesia:	
Under 1 hour	36
1 to 24 hours	28
Over 24 hours	26
Unknown	10
C. Duration of symptoms:	
Under 3 months	26
3 to 12 months	32
Over 12 months	42
D. Number with *x*-ray evidence of skull fracture	40
E. Results of E.E.G. examination:	
Abnormal	6
Within normal limits	54
Not examined	40
F. Symptoms:	
Headache	70
Irritability	50
Dizziness	45
Disturbance of memory	61
Intolerance of alcohol	18

Clinical characteristics of the one hundred cases of head injury.

The E.E.G. tracings were interpreted by the same investigator in every case. The percentage of abnormal tracings (10 per cent.), is no higher than that found in a random sample of the general population (Hill, 1944) It will be appreciated from Table I that, both from the nature and duration of the complaints, this was a relatively chronic series of head injuries.

Normal Controls and Psychoneurotics

As controls, fifty convalescent patients were chosen from the surgical wards of the same hospital. Care was taken in their selection to exclude any who showed signs of neurosis, who had had a nervous breakdown or a head injury, or who might be intellectually impaired from some other medical cause. All abdominal conditions other than trauma were excluded because of the possible association with neurosis; infections of the ear, nose, and throat, and diseases of the cardiovascular system were avoided for the same reason. The majority of the members of this group had been admitted to hospital for the treatment of internal derangement of the knee joint, fractures of the limbs, or gunshot wounds of the soft tissues. The purpose of the tests was explained to each man, whose co-operation was voluntary.

The tendency to attach the label "functional" to any patient whose symptoms were not accompanied by adequate physical signs, was well established before the last war, and psychiatrists had to face the fact that a large proportion of the cases referred to them could not be classified under any of the recognized nosological headings. While the justification for sending such patients to psychiatrist is not questioned, it would clearly be incorrect to regard all such patients as neurotics. The Service psychiatrist is called upon to see an amazing assortment of persons in whom the only common factor is a relative unwillingness to do what is expected of them in the Service; the textbook neurotic is a rarity. It would, therefore, be misleading to collect a neurotic control group except by a process of rigorous selection. In this experiment, fifty neurotics were chosen out of two thousand cases seen in a naval psychiatric clinic. Great care was taken to include only those showing such positive signs and symptoms as would qualify them for admission to one of the recognized categories of neurotic disorder. No case was accepted whose symptoms were attributable to the stress of war alone; the majority gave a history of personality disorder of long standing and many had had nervous breakdowns before joining the Navy. The characteristics of this group is given in Table VIII.

Mental Tests

Tests were chosen with a view to investigating, firstly what will be referred to as the Babcock hypothesis, namely that a difference between the scores on tests of early and recent knowledge is a measure of intellectual impairment, and secondly, the hypothesis of Goldstein, which singles out the inability to deal with abstractions as the fundamental failing in organic intellectual disorder. The following tests were used: (1) the Wechsler verbal emergency, consisting of five subtests: comprehension,

similarities, vocabulary, arithmetic, and the repetition of digits forward and reversed; (2) Trist's progressive shapes sorting test; (3) Weigl's colour-form sorting test; (4) Kohs' blocks.

The contracted Wechsler test was chosen because it is well known, has been used for this purpose by other writers (Reynell, 1944), is short and simple to administer, and is standardized for adults; it was given and scored according to the author's instructions (Wechsler, 1941). Although the two sorting tests were designed for the same purpose, both were given in this experiment as it was hoped that they might show interesting differences; Trist's test was given first in every case and, for the sake of simplicity, these tests were scored on a pass or fail basis. Both tests, which are fully described by the authors (Weigl, 1927; Trist, 1943), are designed to discover the subject's ability to distinguish between a figure and its background. They involve the formulation of a concept based on the recognition of similarities of shape or colour, and they test the ability of the subject to exchange this concept for an equally relevant one by the perception of a different set of relationships. It is theoretically probable that these tests examine, in the visual sphere, a similar ability to that tested by the appreciation of verbal similarities. The first ten subtests of the Kohs' blocks test were included because some writers have found them of particular value in the assessment of organic cerebral conditions (Nadel, 1938; Benton and Howell, 1941; Reynell, 1944). They were administered according to the author's instructions (Kohs, 1923) but were scored on time alone. Owing to the abnormal distribution of the scores, possibly due to the fact that only the first ten subtests were used, the distribution had to be normalized before the calculations were performed. In every case the tests were presented in the order above listed. The time taken to administer the whole battery was a half to one hour.

Effect of Age: Statistical Methods

It is generally agreed that intellectual ability, as measured by mental tests, declines progressively with age (Wechsler, 1941a; Murphy, 1929; Pintner, 1929). The fall is said to be gradual up to about the age of thirty-five but slightly accelerated thereafter. It is also known that the type of intellectual impairment found in cerebral deterioration from disease may also be present in normal senility (Brody, 1942). In order to reduce the possible effect of age alone, the age distribution of the normals and the neurotics was adjusted to make these groups comparable with the head injuries in this respect. It will be seen from the tables that the mean age of the three groups is closely similar. The intelligence level, as determined by means of the Wechsler test from weighted scores, shows that the mean intelligence quotient of each group is what might be expected from a random sample of the general population. The standard errors of the differences between the means of the raw scores was calculated for each of the Wechsler subtests and for Kohs' blocks. A P value of 1 : 20 was regarded as significant, and one of 1: 100 as highly significant. As the sorting tests were scored on a pass or fail basis, the results were compared by means of the χ^2 test on four-fold tables; Yates's correction for continuity was used in these calculations.

Preliminary Comparison of the Test Performance of Controls, Head Injuries, and Neurotics

In Table II the test scores of the head injuries group and the neurotic group are compared with those of the normal controls. A significant difference between the mean scores in the various tests is recorded as follows: (+) indicates a difference, which is significant if direction is taken into account, (++) indicates a probability of 1 : 20, and (+++) a probability of 1 : 100 or over. The best measure of discrimination on the sorting tests between the groups compared was found to be given by failure in both of these tests, to which the percentages on the bottom line refer.

TABLE II

	50 controls	100 head injuries	50 neurotics
Age	29·00	−1·05	−0·80
I.Q. Wechsler	103·02	−3·68	−0·72
Vocabulary ..	25·76	−0·36	+1·50
Comprehension	10·14	+0·03	+0·96
Similarities ..	10·96	−1·32+	−0·06
Arithmetic ..	8·32	−0·62	−0·34
Digits ..	11·64	−1·12+++	−1·04++
Kohs' blocks	3·98	−0·08	−0·08
Sorting tests ..	14%	38%+++	32%

Differences of mean scores of head injuries and neurotics from controls.

The figure recorded for the digits subtest is the sum of the number of digits retained forward and reversed. This figure is given throughout, as no difference was found between the number retained forward, as opposed to the number retained on a reversed series, in any group. This table shows that the results in the case of the head injuries group support the Babcock hypothesis, inasmuch as the scores in vocabulary and comprehension, which are said to depend largely on information acquired in early life, are almost the same in the three groups, whereas in the remaining subtests the head injuries did worse than the controls. The difference is highly significant in the case of the digits and sorting tests, and, in the similarities, is significant if the fact that it is in the expected direction is taken into account. That this apparently specific type of differential failure is not peculiar to the head injuries and cannot, therefore, be exclusively determined by organic intellectual impairment, is shown

by the comparison between the scores of the controls and the neurotics. For, although the neurotics do better than the controls in vocabulary and comprehension, they share with the head injuries group a difficulty in the performance of the remaining tests. Their failure is significant in the digits subtest, and just falls short of significance in the sorting tests. Comparison between the scores of the head injuries and the neurotics showed that, apart from the uniformly higher intelligence of the latter, there was no significant difference between the scores on any of the tests.

It seems, therefore, that the head injuries and the neurotics are affected by some factor or factors which may be common to both, and which affects their ability to succeed in certain intellectual exercises. The following sections are concerned with an attempt to isolate this factor.

Analysis of the Head Injury Series According to the Severity of Trauma

The head injury series was divided into groups according to factors which are commonly regarded as indicative of the severity of the original injury, with the object of determining whether any association existed between these facts of the history and clinical examination on the one hand, and the test performances on the other. The principal clinical characteristics of the head injury patients are recorded in Table I. Of these, the following were chosen for analysis: (A) the presence of abnormal physical signs in the C.N.S.; (B) the length of post-traumatic amnesia (P.T.A.); (C) the length of time between injury and examination; (D) the presence of skull fracture, revealed by radiographs. Before the test performances of these groups are compared, their relationships with each other will be examined.

Post-traumatic Amnesia and Abnormal Physical Signs

In assessing the severity of a head injury it is customary to pay particular attention to the duration of disturbance of consciousness, of which the duration of post-traumatic amnesia is a convenient though subjective measure. While many writers have attempted to establish a positive correlation between the duration of unconsciousness and the subsequent disablement (Ritchie Russell, 1932; Symonds, 1932, 1935; Winkelman and Eckel, 1934; Ruesch, 1944; Kremer, 1944), no unanimous conclusion appears to have been reached.

In ninety members of the head injury series it was possible to make an approximate estimate of the length of post-traumatic amnesia by combining the account given by the patient with that of those who attended him during the early stages of his illness. By this means the following groups were separated:

(i) P.T.A.	Under 1 hour	N. 36
(ii) P.T.A.	1 to 24 hours	N. 28
(iii) P.T.A.	Over 24 hours	N. 26

Thirty-seven of the head injury cases showed abnormal physical signs in the central nervous system. Table III shows the relationship between the length of post-traumatic amnesia and the presence of abnormal physical signs.

TABLE III

P.T.A.	C.N.S. abnormality
(i) (Under 1 hour)	6 (17%)
(ii) (1 to 24 hours)	9 (32%)
(iii) (Over 24 hours)	17 (65%)

Association between length of P.T.A. and C.N.S. abnormality.

There is clearly a direct relationship between these factors; for example, the difference between groups (i) and (ii) combined on the one hand, and (iii) on the other, is highly significant ($\chi^2=12{\cdot}43$ $+++$).

Time Between Injury and Examination

As none of the head injury patients had recovered from their illness at the time they were examined, it was not possible to make comparisons based on the total length of their illnesses. But, by calculating the time between the date of injury and the date of examination and testing, some measure of the chronicity of their condition was obtained. When the series was divided into three groups on this basis (see Table I) it was found that no significant association existed between the chronicity and any of the other factors considered in this section. While some association between chronicity and the severity of trauma might have been expected, this negative finding is in line with that of Ritchie Russell (1934), who showed that a long period of unconsciousness was not associated with a long period of disability.

Presence of Skull Fracture

The importance of the presence or absence of a fracture of the skull in the assessment of post-traumatic disablement is a point on which there is still no general agreement, although many writers have expressed unequivocal opinions on the subject. Adolf Meyer (1904) says: " Whether the cranium is fractured or not means relatively little. It would seem, however, that for chances concerning life, a relatively extensive destruction of the skull is rather

more favourable than otherwise." Foster Kennedy (1932) gives *x*-ray evidence of skull fracture first place in a list of absolute criteria of head injury sufficient to produce organic change in the brain. Ritchie Russell (1932) says: "It is generally admitted that the degree of damage to the skull gives no definite indication of the degree of damage to the brain." While Denny Brown (1945), analysing a series of two hundred head injuries, found that the presence of a fracture of the skull was associated with a significant delay in recovery but regarded it, nevertheless, as a relatively unimportant indication of injury to the brain.

Forty of the head injury series were found to have had a skull fracture, which had been confirmed by *x* ray; the relationship between the presence of a fracture and the length of post-traumatic amnesia is shown in Table IV.

TABLE IV

P.T.A.	Skull fracture
(i) (Under 1 hour)	14 (39%)
(ii) (1 to 24 hours)	9 (32%)
(iii) (Over 24 hours)	16 (62%)

Relationship between skull fracture and length of P.T.A.

Comparison between the combined groups (i) and (ii), and (iii) gives a significant result ($\chi^2=3{\cdot}95$ ++), suggesting a positive association between skull fracture and a long period of unconsciousness. A significant association was also found between skull fracture and the presence of abnormal physical signs in the C.N.S., for, of those patients with abnormal physical signs, 65 per cent. had also fractured skulls. This comparison yields a χ^2 of 13·53 +++.

Summarizing this section: analysis of groups formed by dividing the head injury series according to facts of the history and clinical examination probably related to the severity of the original injury, shows that there is a direct association between the length of post-traumatic amnesia, the presence of abnormal physical signs, and fracture of the skull. These findings are interpreted as lending support to the view that both a long period of unconsciousness and a fracture of the skull are indications that the brain has been damaged.

Analysis of the Test Performance of Head Injuries, Grouped According to Facts Associated with the Severity of Trauma

Table V shows the comparison between the results of tests of the head injuries, grouped according to factors associated with the severity of trauma, and the controls. It will be seen from this table that the group giving the most abnormal test picture is that composed of those head injury subjects in whom

TABLE V

	50 controls	37 C.N.S.	36 (i)	28 (ii)	26 (iii)	26 1.	32 2.	42 3.	40 fracture
Age	29·00	+0·16	−2·40	+1·55	−2·75	−2·58	−0·91	−0·21	−2·12
I.Q. Wechsler	103·02	−7·24 ++	+2·07	−1·56	−10·02 ++	−0·02	−5·60	−4·95	−2·24
Vocabulary	25·76	−1·06	+1·32	+0·57	− 1·83	+1·82	−0·23	−1·19	−0·28
Comprehension	10·14	−0·36	+1·55 +++	+0·15	− 1·79	+0·86	−0·42	−0·14	+0·14
Similarities	10·96	−2·58 ++	+0·30	−0·96	− 1·82 ++	+0·31	−1·05	−2·53 +++	−0·96
Arithmetic	8·32	−1·32 ++	+0·04	−0·43	− 1·28 ++	−0·28	−1·04 +	−0·58	−0·34
Digits	11·64	−1·64 +++	−0·67	−0·89	− 1·49 +++	−0·99 +	−1·36 +++	−1·02 +	−0·94 +
Kohs	3·98	−0·20	+0·38	−0·27	− 0·29	−0·10	−0·17	−0·22	+0·12
Sorting tests	14%	54% +++	31%	46% +++	46% +++	35%	41% ++	38% ++	45% +++

Differences of mean scores of head injury subgroups from controls.

C.N.S. = Head injuries showing abnormalities in the C.N.S.

(i), (ii), (iii) = Duration of P.T.A. { 0 to 1 hour. / 1 to 24 hours. / Over 24 hours.

1., 2., 3. = Length of time between injury and examination. { under 3 months. / 3 to 12 months. / over 12 months.

abnormal physical signs were found; their significantly lower I.Q. is due mainly to failure in the similarities, arithmetic, and digits subtests. Although no case of gross aphasia was included in the head injury series, it is possible, as other writers have pointed out (Wechsler, 1941b; Patterson, 1944) that the difficulties experienced by some head injury patients in certain forms of intellectual activity may be due to damage to the speech mechanism. It was shown, in the previous section, that there was a close association between the presence of abnormal physical signs in the C.N.S. and the length of P.T.A. There is, therefore, bound to be some overlap between these groups; in fact, seventeen of the patients with a P.T.A. of over twenty-four hours also showed neurological abnormalities. Columns (i), (ii), and (iii) show that differential failure of the expected kind becomes more marked with increasing length of P.T.A., and suggests that some factor associated with the length of P.T.A. is reducing the capacity to succeed in the tests. These findings are of some practical value, inasmuch as they provide objective evidence in support of the clinical impression that the duration of P.T.A. is a valid criterion in the assessment of disablement after head injury. In columns 1, 2, and 3, the head injuries are grouped according to the length of time between the date of injury and the date of examination. Although the differences are not so striking as in the case of P.T.A., there is a tendency for the more chronic groups to do less well on the tests than those more recently injured. In the skull fracture group, the differences are not significant except in the case of the digits and sorting tests, but the general pattern of differential failure is preserved.

In conclusion, Table V shows that, by means of mental tests, groups of head injuries, selected on the basis of clinical criteria associated with the severity of their injury, can be separated according to their test performance in a manner which agrees closely with that afforded by clinical assessment. This suggests that the ability to succeed in these tests is influenced by some factor associated both with the severity of the injury and with delay in recovery from its effects.

Analysis of Symptoms

Of the various symptoms that make up the post-concussional syndrome some are commonly regarded as more "organic", others as more "psychogenic", but, as Symonds (1942) and Lewis (1942) have pointed out, no good purpose is served by attempting to make what must be a largely artificial distinction on these lines. Nevertheless, if symptoms could be graded by reference to an objective criterion of cerebral damage, it might be of some help in the classification and possibly in the prognosis of head injury cases. At present, the only objective evidence of post-traumatic disablement, apart from gross neurological abnormalities, is the patient's reduced capacity to cope with the ups and downs of life in general and his work in particular. It was hoped that, by comparing the frequency of symptoms with the more objective facts of the history and examination that have been analysed in the previous section, some indication might be obtained as to the value of individual symptoms in predicting the degree of disablement. This method has been used by Ritchie Russell (1932) with interesting results but, possibly because of the relatively large number of more chronic, polysymptomatic patients in the series under review, no significant correlations could be established.

Before recording the separation afforded by test methods, a brief review of the nature of the principal symptoms is given.

Subjective Disturbance of Memory.—This complaint is usually described by the patient as absentmindedness: inability to recall names, faces, telephone numbers, and, in the Services, orders. Many patients with this complaint mentioned that they had to rely on a notebook for facts which they would formerly have retained in memory. The same disability has been reported in some cases following treatment by hypoglycæmic coma or convulsants (Brody, 1944a; Tooth and Blackburn, 1939), and is similar to the failure of recent memory found in Korsakow's syndrome. It is considered by some to be unquestionably organic in origin (Ritchie Russell, 1932; Osnato and Gilberti, 1927), and its occurrence has been noted by Head (1901) in patients suffering from various other physical conditions. There is no doubt, however, that closely similar complaints are also made by neurotics.

Irritability.—Of the more specific disorders of personality following a head injury, irritability is one of the commonest. Introspective patients describe it as their response to the well-meaning efforts of friends and relatives to push them into activity which they formerly enjoyed but, since their injury, have felt unable to face. Half the members of the head injury series made this complaint of their own accord, and it is probable that the number would have been larger if the opinion of friends and relatives had been available. Although rarely found in simple neurosis, irritability is a common accompaniment of many other physical ailments and may well be a structurally determined, primitive response of the organism, which is seeking a safe hiding-place where the demands of society are minimal and where it can readjust itself in peace. This theory, which

was suggested by Head (1901), will be amplified later.

DIZZINESS.—Subdivision of this group by means of physiological tests might have been worth while had the head injury series been larger, but in the circumstances it was not attempted. Thirty-one per cent. of the patients making this complaint also showed neurological abnormalities, suggesting that, in them, this symptom may have had a physical basis.

HEADACHE.—Of all the symptoms that go to make up the post-concussional syndrome, headache is both the commonest and the least specific. Ritchie Russell (1932) found no significant relationship between the severity of the head injury, as estimated by the duration of unconsciousness, and the frequency or severity of headache. Jefferson (1941) expresses a doubt as to the validity of all headache after head injury, and Cairns (1941) regards it as organic but influenced by emotional and psychoneurotic factors. McConnell (1942) found that headache as an isolated symptom in an otherwise normal person after a head injury was usually associated with sub-dural hæmatoma. In only four of the seventy patients who made this complaint was it an isolated symptom, and in none of these was it severe, or associated with physical signs in the central nervous system.

Relationship between Chronicity and the Frequency and Type of Symptom

While there are clinical grounds for suspecting that the more chronic head injury patients present the most numerous complaints, Table VI shows that this is not wholly true. Comparing the frequency of the symptoms of the three groups formed according to the length of time between injury and examination, it will be seen that, though the most chronic group complain of more symptoms than those more recently injured, the differences are significant only in the case of disturbance of memory and irritability.

TABLE VI

Frequency	61	50	45	70
Symptom	Memory	Irritability	Dizziness	Headache
1. Under 3 months	7	6	9	15
2. 3 to 12 months	22	19	15	24
3. Over 12 months	32	25	21	31
Difference between groups 1 and 3 ..	$\chi^2=13{\cdot}99$ +++	$\chi^2=7{\cdot}19$ +++	$\chi^2=0{\cdot}98$	$\chi^2=1{\cdot}24$

Relationship between frequency and type of symptom and length of time between injury and examination.

Although the opinion of the authorities is not unanimous, there is a tendency to regard the complaints of memory disturbance and irritability as more probably determined by physical factors than headache and dizziness. While no evidence in support of this view could be obtained from the material, a significant association between the chronicity of the condition and the complaints of memory disturbance and irritability, shown in Table VI, is interpreted as evidence that the complaints of even the most chronic head injury patients may have a physical basis.

Analysis of the Test Scores of the Head Injury Series Grouped According to Symptoms

TABLE VII

	61 H. I. Memory	39 H. I. Non-Memory	Difference	50 H. I. Irritability	50 H. I. Non-Irritability	Difference
Age	28·65	26·87	+1·78	29·20	26·70	+2·50
I. Q. Wechsler	97·08	102·46	−5·38	97·20	101·16	−3·94
Vocabulary ..	27·18	26·31	+0·87	25·52	25·28	+0·24
Comprehension	9·84	10·69	−0·85	9·60	10·74	−1·14
Similarities ..	8·47	11·38	−2·91 +++	8·56	10·72	−2·16 ++
Arithmetic ..	7·51	8·08	−0·57	7·50	7·84	−0·34
Digits ..	10·36	10·77	−0·41	10·30	10·76	−0·46
Kohs' blocks	3·87	3·95	−0·08	3·92	3·88	+0·04
Sorting tests ..	46%	31%		44%	32%	

Differences of mean scores of head injuries complaining of memory disturbance and irritability from the remainder of the series.

The figures in Table VII show that there is a tendency towards differential failure of the expected kind in both these groups, but only in the similarities subtest is the difference significant. The fact that the patients complaining of disturbance of memory are able to retain and recall a series of digits almost as well as those who did not so complain is of some interest in that it supports the view expressed by Zangwill (1943) that the retention and recall of a series of digits is not a reliable test of memory. Similar comparisons were made in the case of the groups complaining of headache and dizziness, but no significant difference was found between the scores of these patients and the remainder in any of the tests.

Analysis of the Neurotic Series According to Diagnosis, Symptoms, and Severity

Table VIII shows the principal clinical characteristics of the neurotic series.

In Table II, it was shown that there was a close resemblance between the test performance of the head injuries and the neurotics as compared with the controls. In order to determine whether any particular group of neurotics was responsible for this effect, the series was divided as shown in

Table VIII and the test performances were then compared. The scores of the hysterics and the most severely affected neurotics are compared with the controls in Table IX.

TABLE VIII

DIAGNOSIS:	
1. Hysteria	25
(a) "Constitutional" (i.e.) giving a lifelong history of emotional maladjustment with numerous flights into motivated sickness	9
(b) Pseudo-neurological conversion reactions	6
(c) Hyperventilation hysteria	5
(d) Circumscribed amnesic episodes	3
(e) Hysterical fits	2
2. Anxiety neurosis	18
3. Obsessional neurosis	7
SEVERITY OF ILLNESS:	
1. Severe	30
2. Mild	20
SYMPTOMATOLOGY	
1. Memory disturbance	19
2. Headache	23

Clinical characteristics of the fifty neurotics.

This table shows that the hysterics, compared with the controls, give a pattern of differential failure very similar to that given by the head injuries (see Table II). Direct comparison between the hysterics and the head injuries revealed no appreciable difference in any test; although the similarities subtest went some way towards discriminating between the two groups, the difference did not attain the level of significance ($P = 0{\cdot}2$).

TABLE IX

	50 controls	25 hysterics	30 severe neurotics
Age	29·00	−3·40	−0·67
I.Q. Wechsler	103·02	−1·98	−2·02
Vocabulary	25·76	+0·12	+0·64
Comprehension	10·14	+1·02	+0·79
Similarities	10·96	+0·12	−0·96
Arithmetic	8·32	−0·48	−0·39
Digits	11·64	−1·72 +++	−0·94 +
Kohs' blocks	3·98	+0·06	+0·02
Sorting tests	14%	40% ++	37% ++

Differences of mean scores of hysterics and severe neurotics from controls.

If the inability of the neurotics to carry out certain intellectual tasks was due simply to the general emotional disturbance common to all types of neurosis, it might be expected that those of the neurotics who, on clinical grounds, were judged to be most severely affected, would give the most distinctive type of test performance. Comparison with the controls shows that, while this group gives the characteristic pattern of differential failure, the differences are much less than those given by the hysterics alone.

In order to find out to what extent the hysteric group was determining the pattern of performance of the neurotics as a whole, their scores were compared with those of the remainder of the neurotics and the results recorded in Table X.

TABLE X

	25 hysterics	25 non-hysterics	Difference
Age	25·60	30·80	−5·20++
I.Q. Wechsler	101·04	103·56	−2·52
Vocabulary	25·88	27·80	−1·92
Comprehension	11·16	10·92	+0·24
Similarities	11·08	10·72	+0·36
Arithmetic	7·84	8·12	−0·28
Digits	9·92	11·28	−1·36++
Kohs' blocks	4·04	3·76	+0·28
Sorting tests	40%	24%	P=0·4

Comparison of mean scores of hysteric and non-hysteric neurotics.

It will be seen from Table X that the hysterics are a significantly younger group than the remainder of the neurotics. But, while it is possible that this may account for their slightly lower score in the vocabulary subtest, it is most unlikely to have influenced their performance of the digits subtest, in which alone the difference is significant. It would seem, then, that the hysterics are responsible for most of the difference between the full neurotic series and the controls. Similar comparisons were made between the test performances of those neurotics who complained of memory disturbance and headache, both with the remainder of the neurotic series and with the controls; no significant difference was found by this method of subdivision in any of the tests.

Summarizing this section: it has been demonstrated that a selected series of neurotics gives a pattern of differential failure in mental tests similar to that shown by head injury patients, when both are compared with normals. By dividing the neurotics into groups according to the form of neurosis, its severity, and the complaints of the individual members, it is found that those diagnosed "hysteria" give a pattern of abnormal performance

most nearly approaching that of the head injuries. This finding suggests the existence of a common factor in hysteria and the after-effects of a head injury.

Discussion

Differential testing has been used for demonstrating what has been assumed to be organic intellectual impairment in a number of medical conditions, including post-traumatic states. The method is based on the specific inability of patients suffering from these conditions to succeed in certain tests, while their performance of others is unaffected. It is found to hold good when applied to groups of patients after head injury, and it can be assumed that the performance of the group is representative of the individuals of which it is composed. But, with the exception of two tests, the retention and recall of a series of digits and the performance of simple sorting tests, the method does not give sufficient quantitative discrimination between head injuries and normals to be of much practical importance in the assessment of the individual case. Furthermore, in these two tests, a difference of as great a magnitude was found between the normal controls on the one hand, and a series of neurotic patients in whom no organic condition was known to exist on the other. The Wechsler, vocabulary, and comprehension tests appear to be almost equally efficient measures of ingrained knowledge, in so far as they are done equally well by every group examined. The digits subtest and the sorting tests discriminate to some extent between the various clinical groups, but, as the differences between normals and head injuries and normals and neurotics are so similar, these tests would seem to be of only limited value in the assessment of head injuries. It is possible that the discriminative function of the sorting tests could be improved by taking qualitative differences into account in scoring.

The similarities, and, to a lesser extent, the arithmetic subtest, are the only ones in which the poor performance of the head injuries is not matched by the neurotics. Of the two, the similarities would seem the more worth while for further investigation and development, as it is difficult to believe that even simple arithmetical ability is not, to an appreciable extent, influenced by practice and education. The modified Kohs' blocks test gave no significant difference between any of the groups examined but, although it is outside the scope of this investigation, most interesting qualitative differences of performance were found between various members of all the groups in this test, and it might well be worth while devising methods for recording and classifying these.

Conclusions

The association between test performance and the facts of clinical observation makes it probable that the tests are measuring some factor or group of factors unfavourable for recovery after head injury, but beyond this the interpretation of the results must be mainly speculative. As most of the tests were verbal, it is possible that minor degrees of aphasia may have accounted for some of the failures among the head injury cases, but this would hardly explain all the findings. The nature of the disorder of intellectual function responsible for the distinctive test scores can only be conjectured. As the same pattern of performance is shown both by the neurotics and the head injuries, the common factor can hardly be " organic impairment " in the sense in which this term is used by other writers describing similar findings in general paralysis, cerebral arteriosclerosis, and such like irreversible, deteriorating states. It is, of course, possible that the specific performance of the head injuries was due to organic impairment and that of the neurotics to some unknown factor associated with neurosis but not necessarily with head injury. This explanation cannot be refuted on the data presented in the investigation, but, if it were true, it would raise a doubt as to the value of differential testing for any purpose, for it is virtually impossible to exclude the existence of latent neurosis in anyone; moreover it is well known that tests and examinations are likely to bring out neurotic propensities in otherwise normal persons. Affective disturbances are commonly accompanied by preoccupation and inhibition in the intellectual sphere, and might well influence the performance of tests; but, if this were the explanation of the similarity between the test pattern of the two series, it is surprising that the hysterics, who of all neurotics show the least affective involvement, should give a picture most nearly matching that of the head injuries cases.

An hypothesis to fit the facts presented would need to take account of this similarity between some head injuries and some hysterics. It will be generally agreed that hysteric symptoms are not uncommon after head injury, but, if the specific features of the test performance of the head injuries is attributable to cerebral damage, it is difficult to account for similar findings among hysterics without invoking somewhat speculative theories. There is, however, one outstanding work which links hysteria with organic disease and lends weight to the hypothesis that a type of hysteria may be determined by purely physical factors. In his Goulstonian Lecture of 1901, on " Certain Mental Changes that Accompany Visceral Disease ", Henry Head (1901) describes a

series of patients who, during the course of physical illnesses, showed mental changes. He particularly mentions unaccountable mood swings, often accompanied by paranoid trends, hallucinations, and disturbances of recent memory. He attributes these manifestations to the effects of referred visceral pain and, in his conclusion, excuses himself for indulging in " a fantastic speculation " which amounts to the view that, in certain circumstances, the human organism tends to revert to a primitive type of reaction to illness, and that, when this tendency comes into conflict with the environment, the reaction has all the characteristics of hysteria. The recent experimental studies of Campbell and Parsons (1944) go some way to support this hypothesis. By intracranial injection these workers were able to produce referred pain in normal subjects, whose descriptions of their sensations were closely similar to those of post-concussional patients.

The occurrence of neurotic disturbances, during or after physical illness, is sometimes attributed to the release of such propensities latent in the personality. This explanation would be difficult to controvert, but it fails to account for the not uncommon cases of post-traumatic neurosis in previously stable personalities. It also begs the question of causation. It seems possible that the apparently specific characteristics of the performance of the head injury cases and the hysterics was due to the action of the same primitive mechanism described by Head, activated, in the case of the head injury group, by referred pain from lesions within the cranial cavity. In conclusion, it is suggested that the findings of this investigation can best be interpreted as revealing by mental tests the existence of a type of functional disturbance having the clinical characteristics of hysteria, but organic in origin, and possibly due to referred pain from as yet unidentified changes within the cranium after head injury.

Summary

The method of differential testing, which has been found useful for assessing intellectual deterioration in some organic cerebral conditions, is also widely used for the same purpose in cases of head injury. Differences of performance are interpreted as evidence of organic intellectual impairment, but the absence of objective criteria of damage to the brain in the average post-concussional case makes it difficult to validate such an assumption.

A consecutive series of closed head injuries was compared, by means of a battery of mental tests, with a series of normal people, and a selected series of neurotics. It was found that the pattern of performance of the head injuries was of the expected kind, and that those judged to be most severely injured on clinical grounds gave the most specific type of test pattern. This is interpreted as evidence that the method is testing some factor associated with failure to recover after a head injury.

The investigation lends support to the use of differential testing for analysing the nature of intellectual impairment but, while group differences are clear enough, the deviation of individuals may be so slight or so variable that the method is of limited value in the assessment of the individual case.

As the neurotic subjects showed a pattern of differential failure similar to the head injuries patients, it would seem unjustifiable to conclude that this differential failure is peculiar to organic impairment. The test results of those neurotic subjects diagnosed as " hysteria " most nearly matched the results given by the head injuries patients.

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