

PSYCHOLOGICAL EFFECTS OF STEREOTAXIC OPERATIONS FOR THE RELIEF OF PARKINSONIAN SYMPTOMS

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IN view of their many inter-connections with the cortical grey matter, the effects of lesions in the basal cerebral nuclei are of the greatest theoretical interest. On account of the rarity of naturally occurring lesions confined to these nuclei, there have been few reports of psychological changes in patients with discrete subcortical lesions. Smyth and Stern (1938) described four cases of intrinsic tumour of the thalamus, all of whom gave evidence of organic dementia early in the course of the disease. Eaton *et al.* (1939) reported six cases of symmetrical cerebral calcification preponderating in the basal ganglia, with no radiographic evidence of cerebral atrophy, of which the clinical concomitants included mental retardation. Alford (1948) has gone so far as to insist that destruction of thalamic nuclei is alone responsible for intellectual impairment, and that "focal" defects associated with different cortical lesions are related either to sensory disturbances or to the psychiatric state of the patient.

Experimental subcortical lesions in animals have been associated with changes in performance, though it is questionable to what extent these results are applicable to man. Lashley (1945) investigated the nature of inter-action between different regions of the cortex in the rat by making incisions in the cortical surface, dividing long association tracts. In those animals in which under-cutting of the white fibres resulted in thalamic degeneration, he found a remarkably close association between amount of impairment on maze learning and amount of thalamic degeneration. An experiment which has a more direct bearing on the present study is that of Rosvold *et al.* (1958) involving stereotaxic subcortical lesions in monkeys. The authors noted that "the behavioural deficits which follow certain neocortical ablations in the monkey have not been produced by placing lesions in the thalamic nuclei which project to these neocortical areas". They found that single alternation performance was impaired by caudate-nucleus as well as by thalamic and splenic lesions, and suggested that "a complex and widespread anatomical system rather than a simple and localized one may be involved in successful alternation performance".

The most comprehensive study of the effect of subcortical operations in man on psychological test scores is the study of Riklan *et al.* (1960). Describing the changes in scores on the Wechsler-Bellevue scale of eighty-nine consecutive patients tested a few days before chemopallidectomy or chemothalamectomy and retested within a month after operation, they state that "both the left and right brain groups evidence significant decreases in Verbal and Full Scale I.Q. scores, but only the right brain group demonstrates a significant decrease in Performance scores. Analysis of the subtests indicates that Digit Span is the one most affected, primarily for left brain cases. Trends indicate that the left brain group show greatest decline in Similarities, Picture Completion, and

Digit Symbol tests, while the right brain group is more affected in Picture Arrangement". Elsewhere the authors state "for the left brain group, the three subtests most affected are the Digit Span, Arithmetic, and Digit Symbol tests. For the right brain group, they are the Picture Arrangement, Block Designs, and Object Assembly tests". They also note that there is a significant relationship between impairment of "expressive language functions" (presumably degrees of dysphasia, though no criteria are stated) and Verbal I.Q. loss; and that, apart from laterality of lesion, there are no significant differences in results between lesions in the globus pallidus and in the thalamus, except for slightly greater Verbal I.Q. loss with left-sided thalamic lesions. In forty-nine patients retested about nine months post-operatively, these deficits were no longer in evidence, and there was some slight increase in Performance I.Q. in the group operated on the left.

PRESENT STUDY

The patients represent all those selected for subcortical operation for the relief of unilateral Parkinsonian symptoms who had been referred for psychological testing at the time of writing. There were seventy in all, but four of these were too incapacitated to be able to do any tests. Table I summarizes the results

TABLE I
Mean Pre-operative Scores of Patients

Operated Side	Age	No.	Digit Span	Arithmetic	Similarities	Vocabulary	Picture Completion	Picture Arrangement	Blocks	Sentence Learning	Memory for Designs
Left	49.2	40	1.2	1.1	1.2	1.8	1.9	-1.3	-1.1	10P/4F	2P/4F
Right	52.4	26	0.8	0.7	1.2	2.2	1.6	0.1	1.0	9P/12F	1P/8F

of pre-operative testing on subtests of the Wechsler scales and on Sentence Learning (Zangwill, 1943) and Memory for Designs (Terman and Merrill, 1937). Results on the Wechsler subtests are presented as the means of individual differences (in scaled score points) from the mean score appropriate to the patient's age in the case of the Wechsler-Bellevue scale (Wechsler, 1944, p. 222), or from a mean score of 10.0 using age-scaled scores in the case of the W.A.I.S. The sentence learning test was passed if the patient required not more than five repetitions to learn the sentence to two correct consecutive repetitions; and memory for designs was scored according to IX-year standards, with the proviso that the examiner himself drew the designs, and allowed the patient to study them for as long as he wished before attempting to reproduce them. The patients are grouped according to the side subsequently operated on.

The significance of differences between means has been tested by calculation of "t", and of differences between proportions by the χ^2 method. In view of the large number of these statistics computed, the significance of the difference is not regarded as established unless the statistic exceeds the $p = .01$ level of probability. None of the differences between the groups in the results in Table I is significant at this level: the most significant difference is that of 2.1 points on the Block Designs scores between those with left and those with right-sided operations which, with $t = 2.15$, $.02 < p < .05$, may be regarded as suggestive.

Fifty-six of these patients were made available for retesting, on the same tests as pre-operatively, as soon as they were "up and about", and in any case not more than four weeks after operation. The distributions of differences, in scaled score points, between pre- and post-operative results on five of the

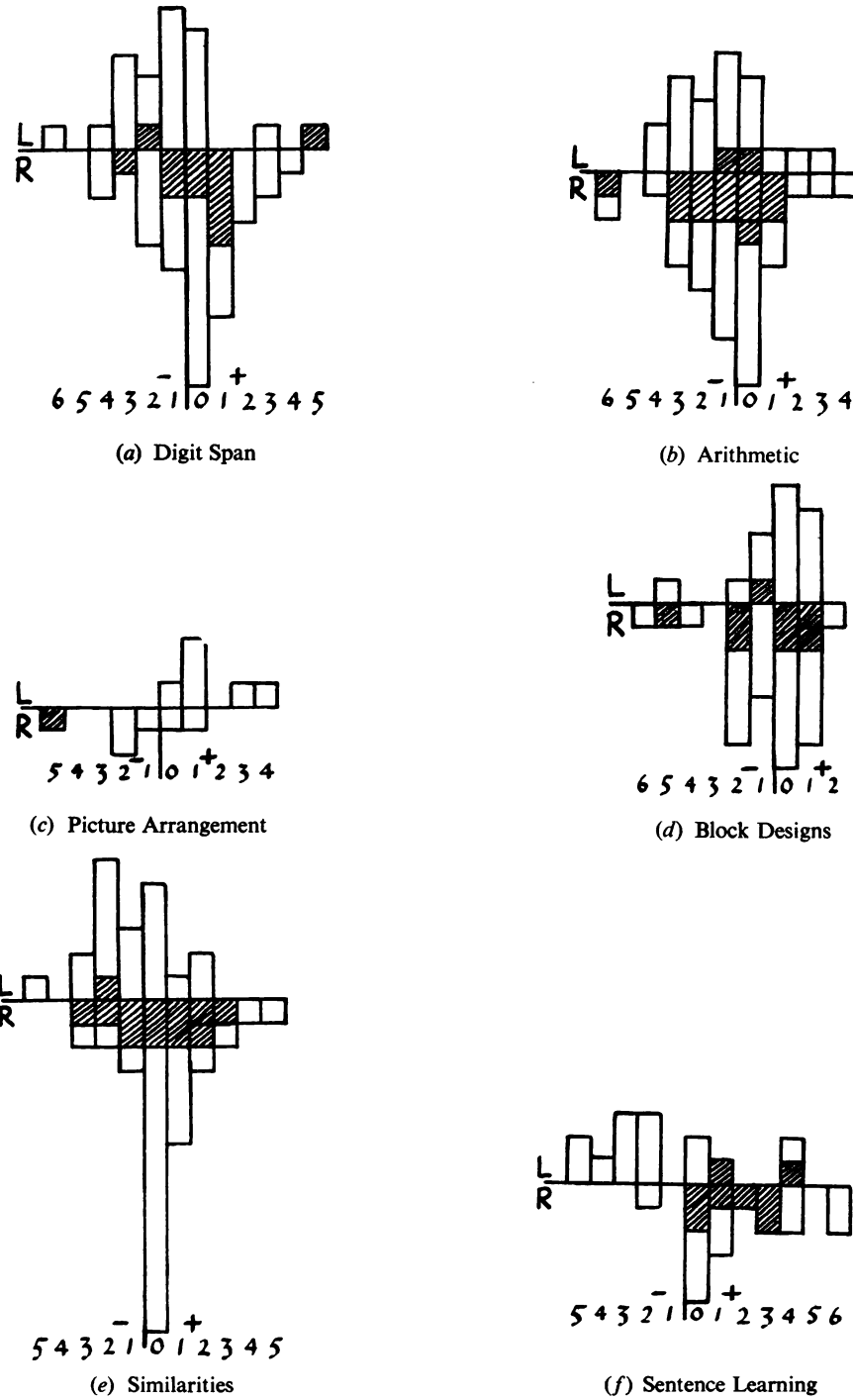


FIG. 1.—Changes in test scores following subcortical operation. In (a)–(e), the units reading horizontally are scaled score points; in (f) they are changes in number of repetitions required to learn the sentence, with sign reversed. The vertical dimension represents the numbers of patients: above the line, those operated on the left; below, those operated on the right. Cross-hatching represents thalamic operations.

subtests is shown in Figure 1, *a-e*, and the distribution of changes in numbers of repetitions needed to learn the sentence is shown in Figure 1, *f*. It will be noted that in nearly all groups, the distributions approximate to normality in shape. The patients have been subdivided according to side of operation, and those who underwent chemothalamectomy (McCaul, 1959) are represented by cross-hatched squares: the remainder underwent electrical thermocoagulation aimed at the globus pallidus (Mr. L. S. Walshe).

Table II shows the mean change in scores of each group of patients,

TABLE II
Mean Changes in Scores After Operation

Side of Operation	Digit Span	Arithmetic	Similarities	Vocabulary	Picture Completion	Picture Arrangement	Blocks	Sentence Learning
Left	-1.2*	-1.2**	-1.2**	-1.0*	-0.7	1.7*	-0.4	-1.7*
Right	0.3	-0.9*	0.4	-0.1	0.1	-1.5	-0.9*	1.7*
Between groups ..	1.5*	0.3	1.6***	0.9*	0.8	3.2**	0.5	3.4***
Total number ..	56	54	50	49	43	12	40	28

Levels of significance of "t" are indicated by asterisks: *, $p < .05$; **, $p < .01$; ***, $p < .001$

and also the difference between these means: the level of significance is indicated of the difference between mean pre- and post-operative test scores for each group, and of the difference between groups in the change in scores.

It will be seen that there are significant differences in post-operative change between those operated on the left and on the right on Similarities, Picture Arrangement, and Sentence Learning, and a suggestive difference on Digit Span and Vocabulary. On the four verbal tests, this is associated with greater impairment following left-sided operation, while on Picture Arrangement there is improvement in those operated on the left and deterioration in those operated on the right. On Arithmetic and on Block Designs, there is impairment after operation in both groups; it is greater on Arithmetic following the left-sided operation, and greater on Block Designs following the right-sided operation.

In view of the statement of Riklan *et al.* (loc. cit.) that pre-operative mental impairment is related to immediate post-operative intelligence loss, we have examined the post-operative results in relation to the patients' abridged Deterioration Quotients (i.e. discrepancy between Vocabulary and Picture Completion, and other subtest scores). Comparison showed that approximately equal proportions of those with and without pre-operative deterioration showed post-operative increase, decrease, and no change in scores.

In eight of the patients operated on the right the personality change after operation was sufficiently striking to have been manifested during testing; but in only one of those operated on the left. The change was generally in the direction of euphoria, not unlike the change seen after leucotomy, but in one of the eight it was mildly depressive. In view of the relatively small numbers of those seen after chemothalamectomy, we have not examined the differences in results between them and those who underwent operation on the globus pallidus: the distribution of their scores, shown in Figure 1, appears to be much the same as those of the globus pallidus group.

DISCUSSION

Comparison of the pre-operative test scores of our patients with normal averages (Table I) shows that, while Vocabulary and Picture Completion scores were, on average, nearly 2.0 scaled score points above the normal mean, scores

on all other tests were considerably below this level. In terms of Wechsler's Deterioration Quotient, this indicates a significant degree of deterioration in the majority of patients before operation. The principles underlying Wechsler's method of estimating deterioration have been supported in a study of patients with localized, mainly cortical, cerebral lesions (McFie, 1960), in which it was demonstrated that, while Vocabulary and Picture Completion scores appeared to be relatively unaffected by cerebral lesions, scores on other tests were selectively affected by lesions in different locations. Compared with the average patterns of deficit found in cases with cortical lesions in different lobes, the distribution of deficits shown by the present series of patients before operation suggests widespread rather than focal intellectual impairment; and this agrees with the observation on ventriculography for location of the stereotaxic instrument, that many patients had slightly dilated ventricles. Exceptional results are those of the patients with right-sided symptoms, whose scores on Picture Arrangement and on Block Designs were rather lower than those of the contralateral group. This is particularly unexpected in view of the fact that in this group it may be presumed that the cerebral lesion is largely left-sided, yet the impairment is most marked on "performance" tests, which are usually most sensitive to right-sided lesions. The explanation probably lies in the fact that the impairment is related not to the cerebral lesion but to the peripheral symptoms, disturbances of movement of the right hand resulting in greatest impairment on performance tests.

Comparison of our post-operative results with those of Riklan *et al.*, shows a considerable amount of agreement. The average age of their patients was very similar to that of ours, and the conditions and time intervals of testing were almost identical with ours. Under these circumstances, it is very encouraging to observe the similarity of results in the two series. In general, the effect of the left-sided operation is a lowering of scores on verbal tests, while that of the right-sided operation is to lower "performance" scores. The findings of Riklan *et al.*, indicate some impairment on Digit Span following right-sided operation: we have not found this in our patients, but for all the other subtests we have been able to confirm their observations.

Changes in test scores after operation may be the result of a number of influences. Some will tend to lower scores, e.g. intellectual or emotional impairment consequent upon the lesion, and possibly impairment of motor control (though this is a rare complication). Others may result in improved scores, e.g. improvement in motor control, personality change of a beneficial kind, and practice effect (if the same test is used in retesting). Evidently, the increases in scores after operation (on Picture Arrangement in the left group and Sentence Learning in the right group) must be the consequence of changes of the latter kind. Improvements in motor control would not improve scores on these tests; and as Riklan *et al.* have suggested conditions are hardly favourable for the establishment of practice effects. This suggests that personality change may be the major influence, and certainly a large number of patients show improved emotional reactions following alleviation of their symptoms. Losses, however, are almost entirely the consequence of the operative lesion, and it is of interest to compare the results with those of lesions in the cortical surface. Riklan *et al.* did not compare their results with published data on the effects of lesions in other parts of the cerebral hemisphere: they consider that "the immediate post-operative losses . . . suggest interference with the more immediate mobilization of mental energy required for learning and integration", and that "the condition of the altered physiologic milieu,

rather than the anatomic damage itself, seems to be of primary importance".

The differences between changes following left- and right-sided subcortical operations resemble closely the differences between effects of left- and right-sided cortical lesions (cf. Anderson, 1948; McFie and Piercy, 1952). As the damage done by the stereotaxic instrument on entering the cerebrum is slight, these changes must be the consequence of the subcortical lesion. It is perhaps not unexpected that thalamic damage should result in some intellectual impairment; but the evidence that similar impairment follows a lesion in the corpus striatum suggests that its functional relationships are not entirely restricted to the motor systems. Furthermore, in the present series of patients the tests on which there is the greatest impairment following the left-sided operation are Similarities, Arithmetic, Digit Span, Sentence Learning and, to a slight extent, Vocabulary; while following the right-sided operation these are Picture Arrangement and, to a slight extent, Block Designs and Arithmetic. If these patterns of impairment are compared with those commonly found in association with lesions in the cerebral lobes (McFie, loc. cit.) it will be seen that they resemble most closely the deficits found with lesions in the left and right temporal lobes. On the face of it, this appears surprising, since the cortex of the temporal lobes receives no direct projections either from the globus pallidus or from the nuclei of the thalamus, which are the targets of the stereotaxic operation. However, recalling the findings in monkeys of Rosvold *et al.* (loc. cit.), it may be that functional relationships between the cortex and subcortical nuclei are more complex and widespread than would be suggested by their direct anatomical connections.

SUMMARY

Subcortical stereotaxic operations for the relief of Parkinsonian symptoms provide an opportunity for the study of psychological changes following lesions in these nuclei.

Fifty-six patients have been tested before and soon after unilateral operation aimed at the globus pallidus or the ventrolateral nucleus of the thalamus. The changes observed are losses on verbal tests following operations on the left and on "performance" tests following those on the right. These results are similar to the types of impairment found with cortical lesions in the same hemispheres.

The significance of these losses, and of certain gains in scores, is discussed.

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