

THE EFFECT OF LEUCOTOMY ON CREATIVE ABILITY.

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TREATMENT by prefrontal leucotomy, though undoubtedly of value, still rests upon an insufficiently scientific basis. Its anatomical and physiological effects are being increasingly discovered, but many of its psychological effects are still unpredictable and obscure. Its effect on intelligence, on immediate memory, and on simple learning ability are now well known, but with these we are not concerned. Rather, we have attempted to assess the effect of leucotomy on "creative ability." By this phrase we shall refer to that ability by which the ideational content of past experience is utilized in a situation to provide concepts and actions not directly evoked by the new situation, but elaborated by the patient's more complex cerebral reactions to the situation. The ability is worthy of examination, since the more intellectual the work the more is it evident. The architect, for instance, needs more creative ability than the bricklayer, the novelist more than the amanuensis, and the Royal Academician more than the house painter.

That this type of activity may be affected by leucotomy has been suggested by the results of frontal lobectomy. In the monkey, for instance, Ferrier (1) noticed more than 50 years ago that after the frontal poles had been removed "a very decided alteration in the animal's character and behaviour had taken place. Instead of, as before, being actively interested in their surroundings and curiously prying into all that came within the field of their observations, they remained apathetic or dull, or dozed off to sleep, responding only to the sensations or impressions of the moment." In human patients with lesions of the frontal lobes, few investigators have made a study of the creative ability of the patients, and the few reports are conflicting. Rylander (2) and Goldstein (3) state that the processes of higher intellectual productivity are less effective in such patients; but the evidence presented on creative ability is meagre. In view of the paucity of facts, we considered it desirable that an investigation should be made into the effect of prefrontal leucotomy on this particular activity.

Investigations already carried out by Hutton and Bassett (4) had suggested that a deficiency in creative ability was shown by leucotomized patients. The tests used for these investigations had been the Rorschach, the Thematic Apperception, the Raven Projection, the Story Telling and the Line Drawing tests, but while these results were suggestive they were not conclusive, and it

was then decided to develop a test which should be more specialized for this purpose. Such a test must satisfy the following criteria :

- (a) It must correlate highly with "creative ability."
- (b) It must be independent of learning, memory and educational status.
- (c) It must be objective in its method of scoring.
- (d) It must yield a permanent record suitable for subsequent examination.
- (e) It must be applicable to all types of patient.

The factors underlying "creative ability" are probably extensive and hardly to be treated adequately by any single method of approach. We are well aware that the proposed test is limited in its scope and that some aspects of creative ability, perhaps even the most important, may elude it. Nevertheless, the results of the test may not be devoid of interest, particularly since it provides some objective facts to supplement the present meagre knowledge.

After preliminary trials a test was devised which depended essentially on the patient's ability to add to a painting imaginative details which were neither present in the example provided, nor suggested by the experimenter. The patient is first given a simple coloured painting which he is asked to copy as exactly as possible, not making any variation. This completed, he is asked to paint the picture again, but now to paint it as he would like to see it ; he is invited, in other words, to add elements neither visible in the example nor described by the experimenter. The difference between the second picture and the first gives a measure of the patient's creative ability. Being a difference, the score is essentially independent of his experience in painting, his innate skill, and his mood of the moment, for all these factors would tend to affect both paintings equally. The paintings are scored from several points of view : the various scores provide measures not only of the patient's creative ability, but also of certain complicating factors. The test has the advantage that by providing means for the measurement of these complicating factors, it enables them to be eliminated.

The "H & B" test was applied to 25 patients, all of whom had undergone prefrontal leucotomy. As a control group the ideal would, of course, have been the same 25 patients before their operation, but this arrangement was not practicable. For control groups we have therefore used 25 normal persons and also 25 psychotic patients who matched as closely as possible the group from which the leucotomized patients were drawn.

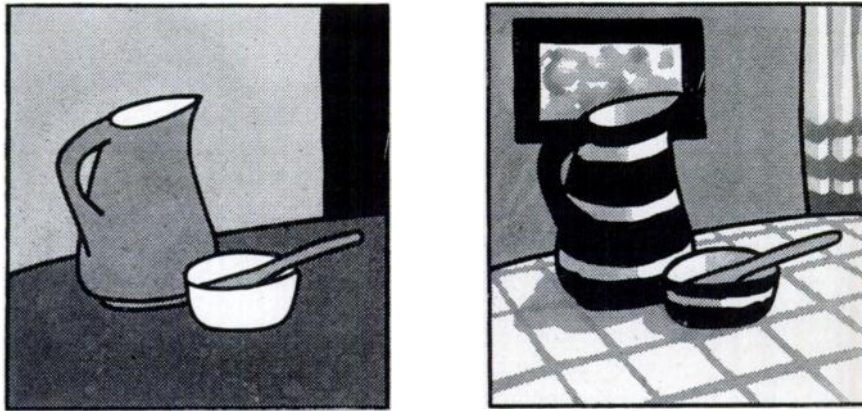
The H & B test will next be described in definitive form.

The H & B Test.

The patient is provided with paint brushes, palette, water, and pots of poster paint in nine colours : brilliant orange, golden chrome, oxford ochre, ultramarine, cobalt violet tint, deep green lake, prussian blue, chinese white, and ivory black. In the first part of the test he is shown a simple coloured painting—the "example."

The example is $3\frac{1}{2}$ in. square, and shows a jug, bowl, spoon and curtain, coloured orange, cream, grey and black respectively, on a background of purple and on a base of pale green. Each colour is even over its whole area, so that

no modulation occurs. A single black line separates the colours. He is then provided with a line drawing which is devoid of colour, but which matches the example in bearing the black outlines of the jug, bowl, spoon and curtain. He is asked to paint into the spaces between the lines so as to copy the example as exactly as possible. To copy the example exactly requires some blending of colours, but the skill required is small: experience with the test confirms that the blending causes little difficulty. The instruction given to the subject is: "Please copy this as exactly as you can. There is no time limit." No further instructions may be given; any query must be answered only by a repetition of the original instruction.



Typical pair of paintings produced by a subject of high creative ability. That on the left closely resembles the example (which is not shown, but is similar); that on the right shows abundant imaginative additions.

When he has finished his copy both it and the example are removed, and the second part of the test is commenced. He is provided with another line drawing identical with the one he has just used, and he is given the instruction: "Paint this as you would like to see it." When this painting has been completed to his own satisfaction the test is complete.

The next step is to convert this pictorial material into numerical scores which measure those five psychological characteristics in which we are interested and on which the data give relevant information. The following 23 criteria are applied (A to I on the first, and J to W on the second painting); each is allotted 1 mark if the answer is "yes," and 0 mark if the answer is "no":

- A-E. Does the colour of (A) the jug, (B) bowl, (C) spoon, (D) background, (E) base, match that of the example?
- F. Do the shapes of the objects approximate to those of the example?
- G. Has any paper been left unpainted?
- H. Has any colour been changed from that of the example?
- I. Has the space in the jug handle been either omitted or painted wrongly in relation to background?
- J. Are any new colours used?

- K. Has the colour of the jug been changed to blue ?
- L. Has any addition been made (excluding those of M N O below) ?
- M. Has a design been applied to the background or base ?
- N. Has a design been applied to any of the objects other than background or base ?
- O. Has shading of any kind been applied ?
- P. Is there any differentiation between the inner and the outer surfaces of either jug or bowl ?
- Q. Has either the handle or the base of the jug been painted a colour different from the body ?
- R. Has purple been used as a flat wash anywhere ?
- S. Has black been used as a flat wash anywhere ?
- T. Have any of the objects been painted out ?
- U. Are jug, bowl, spoon, curtain, all clearly shown ?
- V. Has either base or background been left unpainted ?
- W. Has the space in the jug handle been either omitted or painted wrongly in relation to the remainder of the background ?

The scoring is simple and direct ; each question can be answered by "yes" or "no." These answers are allotted the arbitrary scores of 1 and 0 respectively. Whether the scores are to be taken positively or negatively, and whether the different criteria should be given scores of different magnitudes, are questions which need not be considered at this stage, for full consideration will be given later.

In order to give objectivity to the question "Does the colour match?" and in order to allow a reasonable deviation to the less skilful painters, for each tint in the example a card was prepared bearing two similar tints which showed the limits within which a tint must lie if it was to be judged as "matching."

In order to test the objectivities of the 23 criteria, two experimenters independently scored the final 150 paintings by these criteria. Of the 3,450 (i.e. $2 \times 23 \times 75$) scores allotted, 1,540 pairs agreed and 185 pairs disagreed ; so the agreement was 89 per cent. Since this type of test measures concepts of some complexity, the degree of objectivity reached may be considered satisfactory.

The criteria are not all independent, nor are they intended to be. Criteria A to I, for instance, are linked by the common factor of "accuracy," for they all depend on the precision with which the example has been copied. The 23 criteria are therefore compounded into five basic Sets, each almost homogeneous in its psychological content. These five Sets will now be described.

Set 1 contains the criteria A to I. The characteristic measured is the ability to copy the example with precision. The score for the Set is the sum of the marks for A, B, C, D, E and F, minus the sum of the marks for G, H and I. (The last three marks are given signs opposite to those of the remainder because the last three questions are more conveniently stated in inverted form ; thus a "Yes" in A implies a good colour match and more "accuracy," while a "Yes" in G implies an unpainted part and less "accuracy".) For convenience in reference we have given this Set the arbitrary label of "accuracy."

Set 2 contains the criteria J, K, L, M, N, O, P and U. The score for the Set is the sum of the marks for these criteria. The characteristic measured is the ability to vary from the given example by the introduction of some new element. The measurement of this ability is, of course, our primary aim.

New elements can be introduced either by the addition of objects, the addition of design, the addition of shading, or the alteration of the colour scheme. If new elements are added, their form will, of course, depend on the characteristics of the patient's personality. With these characteristics, however, we are not primarily concerned, since our interest is focussed on the simple ability to add elements which were neither visible in the example nor suggested by the experimenter. We have given this Set the arbitrary label of "creative ability."

Set 3 contains the single criterion T. The characteristic measured is the painting out of objects. The score for this Set is the mark given to T. We have given this Set the arbitrary label of "annihilation."

Set 4 contains the criteria R and S. The characteristic measured is the occurrence of either black or purple in the second painting. The score for this Set is the sum of the marks given to R and S. We have given this Set the arbitrary label of "persistence."

Set 5 contains the criteria Q, V and W. The characteristic measured is the inability to treat the picture as an integrated whole. The score for the Set is the sum of the three marks. We have given this Set the arbitrary label of "omission."

The five Sets thus reduce the performance of each patient to a vector of five numbers; thus patient No. 1 scored [8, 8, 0, 0, 0], while No. 2 scored [2, 5, 0, 4, 4].

The test was then applied to the patients and to the controls. These we will now describe.

The Subjects.

Of the 25 leucotomized patients, 18 were living outside and 7 were still in hospital. The intervals between operation and testing ranged from 4 weeks to 7 years; the average interval was 3 years.

For controls we had two groups: one of 25 normal persons, and one of 25 psychotic and non-leucotomized patients. The latter were selected to resemble as closely as possible the type of patient from which the subjects had been taken for leucotomy. We shall refer to the three clinical types as the "Leucotomized," the "Normal," and the "Psychotic," often using the abbreviations L, N and P.

These 75 persons were subjected to the test. The paintings were scored in the manner defined, and the scores are shown in Table I.

The Results.

The scores will first be analysed to provide the basic facts. Their interpretation will be postponed until the discussion.

The first analysis will ascertain whether the three clinical types (L, N and P) differ significantly in their scores. The Sets will be examined separately; questions which involve their inter-relations will be discussed in a later paper.

TABLE I.—Scores Achieved by 75 Subjects in the 5 Sets.

Subject number.	Clinical type.															Subject number.	Mean score								
	Normal.					Psychotic.					Leucotomized.														
	1.	2.	3.	4.	5.	1.	2.	3.	4.	5.	1.	2.	3.	4.	5.										
1	8										9	7	1			2	5				2	4			
4	11	11				21	10	5			29	10	5			39	6	5	1		5	12	4		
6	4	4				29	6	5	1		39	6	5	1		42	1	6			11	8	2		
9	8	9				42	1	6			44	4	10			44	4	10			13	4	6		
10	6	9				44	4	10			56	0	6			61	2	3			19	6	4		
14	7	8				56	0	6			61	2	3			68	1	7			31	11	2		
15	9	5				61	2	3			70	4	1			71	4	1			37	10	4		
16	5	7				68	4	1			70	4	1			71	4	1			40	4	11		
18	10	5				70	4	1			71	4	1			72	6	3			41	2	2		
23	5	8				71	4	1			72	6	3			73	3	5	1		49	1	6		
28	10	8				72	6	3			73	3	5	1		74	7	5			51	4	9		
32	8	8				73	3	5	1		74	7	5			75	5	0			53	0	4		
33	8	14				74	7	5			75	5	0			76	4	3			55	1	1		
35	7	5				75	5	0			76	4	3			77	0	2			57	11	9		
38	4	6				76	4	3			77	0	2			78	3	6			59	5	7		
33	8	14				77	0	2			78	3	6			80	1	1			62	5	3		
35	7	5				78	3	6			80	1	1			81	6	6			63	4	4		
38	4	6				80	1	1			81	6	6			82	5	1			64	11	8		
33	8	14				81	6	6			82	5	1			83	4	2			65	2	2		
35	7	5				82	5	1			83	4	2			84	5	2			66	1	5		
38	4	6				83	4	2			84	5	2			85	4	4			67	5	6		
43	10	6				84	5	2			85	4	4			86	5	3			79	0	3		
45	10	11				85	4	4			86	5	3				5	11			87	2	7		
46	10	11				86	5	3				5	11								88	0	4		
50	6	7																							
52	11	7																							
54	8	10																							
58	9	11																							
60	11	8																							
7	12	13																							
20	7	8																							
Mean Score	8.2	8.3	0.0	0.08	0.08	Mean score	1.6	4.2	0.32	1.56	1.64	Mean score	4.5	5.0	0.44	1.80	1.84	Mean score							

Set 1.

The mean scores of the three clinical types are :

Leucotomized	.	.	.	4.5
Normals	.	.	.	8.2
Psychotics	.	.	.	1.6

The statistical significance of the differences is shown by the analysis of variance in Table II.

TABLE II.—*Analysis of Variance of the Scores in Set 1.*

Variance.	DF.	Sum square.	Mean square.	Variance ratio.	P.	Significance.
Clinical types	2	534.32	267.16	17.3	<0.001	**
Residual	72	1111.36	15.4355	..	..	..
Total	74	1645.68	..	..	..	..

We shall use throughout Yates' (5) convenient symbolism, where o represents "not significant," * represents "significant at a 5 per cent. level," and ** represents "significant at the 1 per cent. level."

The right hand column of Table II shows that the three clinical types differ in their scores in Set 1 by amounts which are undoubtedly significant statistically.

The comparisons between the pairs of clinical types are made as follows. Since the residual variance is 15.4355, the variance of the mean score will be one twenty-fifth of this, and the standard deviation will be its square root, i.e. $\sqrt{15.4355/25}$, which is ± 0.786 . The standard deviation of the difference between two of the means will be $\sqrt{2}$ times this. The difference will be significant if it exceeds twice its standard deviation, i.e. if it exceeds $2\sqrt{2} \times 0.786$, which is ± 2.22 . Thus the means of the leucotomized and psychotics differ by 2.9; as this exceeds 2.22, the difference is significant. If we indicate this difference by the obvious symbol L/P, we find the significances of the differences to be :

L/P	:	**
N/L	:	**
N/P	:	**

All three clinical types are therefore significantly different from one another in their scores for "accuracy."

The data of Set 1 show, therefore, that the leucotomized are neither as "accurate" as the normal, nor yet as "inaccurate" as the psychotic. The interpretation of the results is discussed later.

Set 2.

This score measures the feature which we have called "creative ability." It is, of course, the characteristic in which we are primarily interested. The three clinical types have mean scores :

Leucotomized	.	.	.	5.0
Normal	.	.	.	8.3
Psychotic	.	.	.	4.2

The analysis of variance of the scores is given in Table III.

TABLE III.—*Analysis of Variance of the Scores in Set 2.*

Variance.	DF.	Sum square.	Mean square.	Variance ratio.	P.	Significance.
Clinical types	2	232.1868	116.09	16.90	<0.001	**
Residual	72	494.5600	6.869	..	..	..
Total	74	726.7468	..	..	..	..

The statistical significances of the differences between the mean scores are found, by the same method as in Set 1, to be :

L/P : 0
 N/L : **
 N/P : **

The data show, therefore, that the leucotomized and the psychotic have considerably less "creative ability" than the normal. The interpretation of this result will be discussed later.

Set 3.

This score measures the feature which we have called "annihilation." The three clinical types have mean scores of :

Leucotomized . . . 0.44
 Normal . . . 0.00
 Psychotic . . . 0.32

The analysis of variance of the scores is shown in Table IV.

TABLE IV.—*Analysis of Variance of the Scores in Set 3.*

Variance.	DF.	Sum square.	Mean square.	Variance ratio.	P.	Significance.
Clinical types	2	2.5866	1.2933	3.638	0.04	*
Residual	72	25.6000	0.3556	..	..	..
Total	74	28.1866	..	..	..	..

As the scores are small integers, varying discontinuously, and as Fisher's z-test is based on the assumption that the variables are distributed continuously and normally, there is some doubt as to whether this test is properly applicable. An alternative test of significance, not using these assumptions, may be made by comparing in the three clinical types how often zero and non-zero scores occur. The frequencies are shown in Table V.

TABLE V.—*Frequencies of Zero and Non-zero Scores in the Three Clinical Types in Set 3.*

Score	Clinical type.			Total.
	N.	P.	L.	
Zero	25	19	19	63
Non-zero	0	6	6	12
Total	25	25	25	75

The χ^2 -test is appropriate here. $\chi^2 \parallel 7.14$, $n \parallel 2$, and $P \parallel 0.03$; so the differences between the three clinical types are significant at the 5 per cent. level, in agreement with the previous result.

The statistical significances of the differences between the mean scores are :

L/P	:	0
N/L	:	**
N/P	:	*

The data shows that the leucotomized score higher for "annihilation" than the normal.

Set 4.

This score measures the feature which we have called "persistence." The three clinical types have mean scores :

Leucotomized	.	.	.	1.80
Normal	.	.	.	0.84
Psychotic	.	.	.	1.56

The analysis of variance of the scores is shown in Table VI.

TABLE VI.—Analysis of Variance of the Scores in Set 4.

Variance.	DF.	Sum square.	Mean square.	Variance ratio.	P.	Significance.
Clinical types	2	12.48	6.24	2.782	0.08	0
Residual	72	161.52	2.243	..	..	..
Total	74	174.00	..	..	..	..

For the same reasons as those given in the discussion of Set 3, an alternative test of significance may be applied to the data in Table VII.

TABLE VII.—Frequencies of Zero and Non-zero Scores in the Three Clinical Types in Set 4.

Score	Clinical type.			Total.
	N.	P.	L.	
{ Zero	17	10	9	36
{ Non-zero	8	15	16	39
Total	25	25	25	75

$\chi^2 = 6.10$, $n = 2$, and $P = 0.04$, which is similar to the value in Table VI. The evidence therefore suggests, without proving, that there is some distinction between the three clinical types in their scores for this character. The statistical significances of the differences between the mean scores are :

L/P	:	0
N/L	:	*
N/P	:	0

The data suggests, therefore, that the leucotomized differ from the normal in the character "persistence." •

Set 5.

This score measures the feature we have described as "omission." The three clinical types have mean scores :

Leucotomized	.	.	.	1.84
Normal	.	.	.	0.08
Psychotic	.	.	.	1.64

The analysis of variance of the scores is given in Table VIII.

TABLE VIII.—*Analysis of Variance of the Scores in Set 5.*

Variance.	DF.	Sum square.	Mean square.	Variance ratio.	P.	Significance.
Clinical types	2	46.4266	23.2133	13.16	0.001	**
Residual	72	126.96	1.7633	..	..	..
Total	74	173.3866	..	..	..	..

For the same reasons as those given in the discussion of Set 3, an alternative test of significance will be applied to the data in Table IX.

TABLE IX.—*Frequencies of Zero and Non-zero Scores in the Three Clinical Types in Set 5.*

Score	Zero	Clinical type.			Total.
		N.	P.	L.	
{	Zero	23	9	9	41
	Non-zero	2	16	16	34
Total		25	25	25	75

$\chi^2 = 21.1$, $n = 2$, and P is less than 0.001. There is therefore no doubt that the differences between the mean scores are statistically significant. The significances of the individual differences between the mean scores are :

L/P	:	0
N/L	:	**
N/P	:	**

The data show, therefore, that both psychotic and leucotomized score for "omission" significantly higher than the normal.

DISCUSSION.

We have now measured the performances of the three clinical types in each of the five characteristics, and we have made the primary comparisons between the three clinical types.

But before discussing the interpretations of these comparisons we must first be satisfied that the psychotic are sufficiently well matched with the leucotomized to be valid as controls. With regard to sex distribution, age and clinical diagnosis, the two groups are as follows. In the leucotomized group there were 11 males and 14 females, and in the psychotic group there were 12 males and 13 females. The average age of the leucotomized group was 41

years, the average age of the psychotic group was 54 years. In the leucotomized group there were 10 schizophrenic patients, 6 obsessional patients, and 9 others. In the psychotic group there were 10 schizophrenic patients, 4 manic-depressive patients, and 11 others. It has been shown that in four out of the five characteristics the two groups do not differ significantly. Of the 25 psychotic controls, 4 have since been leucotomized, and 2 more have been recommended for the operation. We may conclude, therefore, that the two groups are reasonably well matched.

The next question to be discussed is whether the test, as a means of detecting changes in creative ability is adequate.

Is the score in Set 2 determined chiefly by "creative ability" and not by some other factors? The test can measure this ability only partially, but the score in Set 2 seems to be determined chiefly by this ability. Thus the criteria determining the score in Set 2 are J, K, L, M, N, O, P and U. All these criteria measure the patient's ability to add elements which have been elaborated by his more complex cerebral reactions from the ideational contents of his past experiences. The score in Set 2 of the test may, therefore, justly be claimed to be determined by creative ability as defined in this paper and not by some other factor.

The sensitivity of the test must be discussed, since a failure to show a difference between two groups might be due to a coarseness of the measuring device. Our experiment, however, demonstrates that the test is sufficiently sensitive to show significant differences between the normal and the leucotomized in all 5 characteristics, between the normal and the psychotic in 4 out of the 5 characteristics, and between the psychotic and the leucotomized in 1 of the 5 characteristics. There seems, therefore, little reason to doubt that if a major difference existed between the leucotomized and the psychotic in "creative ability" then this difference would also have been detected. The test therefore appears to be sufficiently sensitive.

Since we have now shown that the test is both sufficiently specific and sufficiently sensitive we may turn to the data in their relation to the main subject of the paper.

What is the effect of prefrontal leucotomy on creative ability? The results of Set 2, stated earlier, showed that the three clinical types had mean scores—

Leucotomized	.	.	.	5.0
Normal	.	.	.	8.3
Psychotic	.	.	.	4.2

The differences N/L (3.3) and N/P (4.1) were significant, while L/P (0.8) was not. What deductions may be drawn?

It is clear from the results that the presence of a psychosis is itself sufficient to cause a marked decrease in creative ability as measured by our test. The psychotic obtains, on the average, only a half of the score obtained on the average by the normal, and this difference is significant statistically.

This fact must be allowed for when we interpret the score of the leucotomized. The fact that the leucotomized score was significantly lower than the

normal might suggest that the operation was responsible for the fall in score. But before operation the patients in the leucotomized group were themselves psychotic, so the effect of the operation will be best shown, not by comparing the leucotomized with the normal, but by the comparison between leucotomized and psychotic. The difference between their mean scores is small (0.8) and statistically insignificant. *The evidence suggests, therefore, that the operation per se does not tend to lower the score for creative ability.*

How does this conclusion agree with the work of other investigators? As far as is known, no other systematic work on creative ability has yet been done. Such other evidence as is available will, however, be collected and described briefly.

Freeman, who has had extensive experience of the results of leucotomy, thinks that creative ability, while sometimes impaired temporarily by the operation, is not permanently affected: "The capacity for imagination appears to be reduced to some degree following pre-frontal lobotomy, but by no means in the measure that it does following lobectomy reported by Rylander and others. There is a period following the operation when the imagination is decidedly dulled, although later on it returns to a considerable degree so that constructive intellectual work of high calibre can be performed." (6)

He supports this contention by a detailed description of his Case 34. The patient was a man, aged 54, and a tool designer. As a young man he was described as brilliant, imaginative and sensitive. Prefrontal leucotomy was performed for the relief of severe obsessional neurosis. Later he invented an elliptical wheel-dressing device which was patented twelve months after the operation. Freeman states that the patient finally showed not only good judgment, but initiative and imagination.

Three other cases are also mentioned by Freeman (6) (Nos. 58, 42, 50), in which constructive intellectual work has been performed after leucotomy.

Vencowsky and David (7) have reported the appearance of creative artistry in three cases after the operation, but no details are at present available.

Reitman (8) (9) has described two cases in which a creative spell has occurred after leucotomy; he finds that "the operation gave stimulus to the personality, developing its artistic reactions." "There is little doubt that the creative spell was activated by the operation." While the relevance of his observations to ours is difficult to determine, there remains, nonetheless, his demonstration that creative activity is not rendered impossible by leucotomy.

CONCLUSION.

Though the series studied by us is small, and though the subject of "creative ability" is too large to be explored adequately by one investigation, yet the investigation reported here can claim some advantages over the somewhat scattered observations and impressions which have been published. The test we have used was specially devised to test this function objectively. Evidence internal to the test suggests that it is both sensitive and specific. The results given by it point uniformly to the conclusion that creative ability is not markedly impaired by prefrontal leucotomy. The facts elicited by other workers are not considered to be incompatible with this conclusion.

SUMMARY.

We have investigated the extent to which creative ability is impaired by prefrontal leucotomy, and have devised a test to explore this function objectively. The results are valid only for that aspect of creative ability which is accessible to our test.

Seventy-five subjects were tested in this way—25 leucotomized patients, with 25 each of normal persons and psychotic patients as controls.

The 3,450 scores were analysed. The results are described in detail in the paper.

They show no evidence that creative ability is impaired by prefrontal leucotomy.

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