

A COMPARISON OF THE PERSONALITY CHANGES AFTER (1) PREFRONTAL SELECTIVE SURGERY FOR THE RELIEF OF INTRACTABLE PAIN AND FOR THE TREATMENT OF MENTAL CASES; (2) CINGULECTOMY AND TOPECTOMY.

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INTRODUCTION.

EXTENSIVE lesions of the frontal lobes are followed by pronounced personality changes. This has been shown beyond doubt by the effect of neuro-surgery performed for the removal of brain tumours or for the relief of mental illness. To identify such changes and the lesions responsible for them at least four conditions seem necessary:

(A) *Knowledge of the limits, variations and connections of the main pre-frontal areas.*—In this field the researches of Professor Alfred Meyer and his associates, Mrs. Beck and T. McLardy, are of primary importance (1950).

(B) *Relatively normal patients.*—The results with chronic or deteriorated psychotics do not lend themselves to reliable objective analysis (Crown, 1951). In contrast, intractable pain patients or neurotics—reported on in this paper—appear to present much more meaningful information regarding frontal lobe function.

(C) *Selective prefrontal operations.*—These can now be achieved with the open techniques. Careful post-operative radiological assessments of the limits of the section or excision, on a large number of patients, yield satisfactory anatomical information, with reasonable certainty.

(D) *Knowledge of the dimensions of personality, along which psychological measurements can be made; and objective psychological tests to carry out such measurements sufficiently sensitive to register changes caused by frontal lesions.*—In this field the work of Eysenck and his associates (1947, 1952) and Cattell (1950)—on personality tests related to the factors that have so far been identified—is of particular importance.

The consistent personality changes—as measured by objective psychological tests—following on different types of prefrontal operations are described in a recent publication (Petrie, 1952b). The important differences in the effect of the various techniques is also noted. These operations were carried out on patients in England by Mr. McKissock. In this paper the effects of two other selective operations are presented and compared. These were topectomy of the convexity and cingulectomy performed by one of us (J.L.B.) on French patients.

On the basis of the results of leucotomy on English patients referred to above (1952b) and the observed clinical effects of these two new operations the following hypotheses were postulated:

(1) Changes in temperament and character after Le Beau's *convexity* operation would be of the same basic pattern as that found after the different operations already studied in England.

(2) The extent of the personality changes would be smaller after the French operation than after the English Rostral, as the former is more circumscribed.

(3) The loss on intellectual tests found after the Standard operation in England would not be present following on the circumscribed operation in France.*

* The French convexity operation involves primarily area 9 and 10 and is even more circumscribed than Mr. McKissock's Rostral, which also did not cause a loss on intellectual tests.

(4) After operations carried out for the relief of intractable pain, personality changes would be of the same pattern as those found after operating in the treatment of severe neurosis.

(5) Whilst a similar pattern of personality changes would result from all lesions in the granular cortex, a new pattern of changes might emerge after a lesion which did *not* affect the granular cortex—that is, after cingulectomy.

The results on the 35 patients examined before and after operations carried out by one of us lend support to these hypotheses.

THE OPERATIONS.

The operations are of three types: (a) convexity, (b) cingulectomy, (c) mesial undercutting. They are all bilateral. All the patients were operated upon by one of us (J.L.B.) in Paris since 1947. Detailed psychological testing was started there in 1950. The psychological techniques were designed, the psychological testers trained and the results analysed in London.

(a) *The Convexity Operation.*

This is the original topectomy as practised by Pool in New York in 1946 (Le Beau *et al.*, (1950)). The only important difference is that his patients are mostly psychotic, while our own population is richer in neurotic and pain cases. The operation is well known now and there is no need to describe it again. Only the following points need be stressed:

1. Either area 9, or area 10, or both are involved. Sometimes a part of the orbital surface (area 11) is encroached upon, but the operation never goes as far back as area 8. (For the meaning of Brodmann's numbers and the advantages of using them see Le Beau (1951).

2. Either topectomy (cortical resection) or subcortical undercutting (Scoville's technique) was used. Topectomy was performed by excising the cortex and its arteries, or by a type of subpial dissection (decortication) which avoids the arteries and thus is possibly more selective. Sub-cortical undercutting, when involving both areas 9 and 10, is similar to McKissock's Rostral leucotomy, although it does not cut as much on the orbital surface nor in the region of areas 9/8; its lateral extension also seems to be smaller.

3. Therapeutic results after a period of one to five years have been published previously (Le Beau, 1950a). It is only necessary to repeat that the convexity operation seems especially successful in anxiety neurosis and many kinds of intractable pain. From the evidence collected to date the patients are not noticeably incapacitated socially by the operation.

4. A detailed study of the immediate post-operative syndrome was recently published (Le Beau, 1952). Typically it is a hypomanic state with the euphoria, joking tendency, sphincter disturbances and general carelessness of the classical "frontal" syndrome. This appears to be related more to the suppression of area 9 than of area 10, but particularly noticeable is the pronounced contrast between this "convexity" syndrome and the "mesial" syndrome, described below.

90 patients were submitted to the convexity operation since 1947 and clinically studied. Of these, 70 were topectomies and 20 were under-cuttings.

(b) *Anterior Cingulectomy.*

The operation was first performed in 1948 with the definite purpose of quietening the states of anger, agitation and violence, which were apparently unrelated to anxiety. Its technique and results were described eighteen months later (Le Beau *et al.*, 1949) and again in considerable detail by the same authors in 1950. Then the results of cingulectomy in epilepsy with character disorders were reported (Le Beau, 1950b); and, by the same author, its effects in psychosis and in obsessive states (1951), and finally a detailed study of the post-operative syndrome (1952). The following points seem important enough to be re-stated:

- (1) Usually area 24 is removed, just above and in front of the anterior part of the corpus callosum. Often area 32 is involved, sometimes area 12 situated under 32, rarely area 25 under the genu of the corpus callosum.

- (2) Technically it is a decortication avoiding the arteries; and as both left

and right areas are removed with a unilateral approach the veins of only one side need be interrupted. Thus the operation is really selective.

(3) Long term therapeutic results show the effectiveness of the operation in the above-mentioned conditions, with the exception of chronic psychosis such as schizophrenia, where it fails. One of its chief advantages is the apparent absence of undesirable mental effects, in comparison with the other operations.

(4) The post-operative syndrome during the first few days is apparently free from the indifference and euphoria caused by the convexity operation. Usually there is little to note, except, on occasion, some apathy or even some slight agitation. In general, the patient appears to be much more "himself" than after any other pre-frontal operation.

This operation has been performed on occasion in the U.S.A. (Pool, 1947, and Ward 1948), but the only other detailed report we know of has just been published in England (Whitty *et al.*, 1952). The welcome article of the Oxford workers confirms almost all that we published previously (Le Beau *et al.*, 1950). Three differences between their work and our own are, however, noticeable; the operation was not tried on epileptics with character disorders; it was often used in schizophrenic states where we prefer mesial undercutting; and they report that it reduces anxiety, while we believe its value lies in its other effects, described above.

Thirty cingulectomies have been performed by one of us (J.L.B.) and clinically studied since 1948.

(c) *Mesial Undercutting.*

This type of mesial operation follows Scoville's technique, with some differences:

(1) Areas 32, 24 and often 12 are undercut, which necessitates undercutting in addition either the mesial part of 9 or 10 or both. Although the operation is thus less extensive than the complete mesial undercutting, it is far less selective than cingulectomy, since it always involves some part of the convexity.

(2) In order to be selective, as few arteries and veins as possible, on both the left and right convexities, should be damaged.

(3) Results seem specially good in obsessive compulsive neurosis. In schizophrenia with aggressive tendencies the operation often needs to be completed by a convexity undercutting (Le Beau, 1951).*

(4) The post-operative syndrome may exhibit some of the features of the convexity cases, chiefly when the cut goes through area 9 rather than 10; apathy and incontinence seem to follow an orbital extension of the mesial cut (Le Beau, 1952).

15 cases have been submitted to the mesial undercutting operation since 1948. All were clinically studied before and after the operation.

PATIENTS WHO WERE INVESTIGATED BY PSYCHOLOGICAL TECHNIQUES.

The psychological changes in respect to 34 patients are detailed below.

18 patients underwent convexity operations; 10 of these were suffering from intractable pain and 8 were mental cases. (9 of these patients with convexity operations had undergone topectomy and 9 were subjected to subcortical undercutting.)

10 patients were subjected to cingulectomy. All but two of these were epileptics.

In addition, six patients were examined who had mesial undercutting which anatomically falls midway between cingulectomy and the convexity operations. Three of these were pain cases, three were mental cases.

PSYCHOLOGICAL TECHNIQUES.

Two French psychological testers—Mrs. Namin and Mrs. Stewart—were trained by one of the writers (A.P.) to carry out in Hôpital Lariboisière the investigations

* We have recently heard of a series of mesial undercutting operations performed on deteriorated mental patients by Livingstone of Portland, Oregon, U.S.A. (1952). Although results are not yet published we understand that, therapeutically, they are considered to be satisfactory.

identical with those found fruitful in England. The same method of administration was retained in order to make possible comparisons of the two sets of results.

Patients were examined shortly before and one to four weeks after the operation. A third examination was carried out six to eight weeks after the operation. The changes shown at this third examination in comparison with the pre-operative condition are reported in the results. Reference may be made, however, to the results of the fourth investigation—which has already been carried out on some of the patients, after an interval of 7 to 9 months—as providing confirmatory evidence of the changes reported.

The second investigation was purposely carried out as soon as possible after the lesion in order to try and obtain an idea of what might be happening before adaptation to the deficit occurred. From the therapeutic aspect we are, however, chiefly interested in the more permanent alterations in the patients presented at the later investigations—which we have been able to show persists after an interval of months and years (Petrie, 1949*b*, 1952*a*).

The personality tests were chosen to include five variables related to the factor of "neuroticism" and five variables related to the factor of "introversion." Among these were tests of suggestibility, manual dexterity, self-criticism, perseveration, speed of writing, self-blame, attitudes to time, appreciation of humour and the preference for accuracy or speed. In addition, estimates of intervals of time were obtained. The intelligence tests used were Wechsler-Bellevue Form II, Verbal and Performance Scale and Porteus Mazes.

The difference between pre-operative and post-operative scores has been calculated in each case. For the small sub-groups predictions were made—on the basis of hypotheses 1 to 5 presented above—as to the direction of the change on all the relevant variables. The Binomial Test was used to ascertain the significance of the changes found. Further, in order to measure the significance of the changes on the individual personality tests, Lord's modified "t" test was used (1947).* The level of significance used throughout is that the probability is less than 1 in 20 that such a change would have occurred by chance.

RESULTS OF THE PSYCHOLOGICAL INVESTIGATIONS.

a. i. *Convexity Patients* (Areas 9 and 10).

18 patients have been examined who were subjected to convexity operations, involving areas 9 and 10. All five variables related to "neuroticism," and all five variables related to "introversion" changed in the predicted direction. The changes were highly significant according to the Binomial Test (less than .01). The post-operative personality changes after Le Beau's convexity operations are thus of the same basic pattern as that found after the English operation. The individual test changes on the 18 French convexity patients do not, however, reach the level of significance, whilst on the 15 English Rostral patients the changes are significant on each of the ten variables. The mean changes are, in fact, less pronounced after the less extensive French operation than after the more extensive English operation.*

On the intellectual tests improvement is shown on both the Performance and Verbal scale of the Wechsler, though it is, as expected, more pronounced on the former (Petrie, 1949*a*). Porteus Mazes also shows some improvement. Thus, the circumscribed French operation differs from the Standard English in its effects on the intellect in that no loss was shown on the intelligence tests used. In this it is the same as Mr. McKissock's Rostral operation, which also caused no loss on these intelligence tests (Petrie, 1952*b*).

* In calculating the significance of the changes on the individual personality tests after prefrontal lesions a one-tailed test was used. This was based on the seventy patients—already examined after such lesions—having demonstrated clearly and consistently the direction of these changes (Petrie, 1948, 1949*c*, 1950, 1951, 1952*a*).

* These results, in addition to confirming the hypothesis of the direct relationship between the extent of the lesion and that of the personality changes, are of further interest. If there was any basis to the supposition that practice effects are mainly responsible for the changes found, then the greater the number of investigations, the more pronounced should be these changes. We have found the contrary to be true. These French patients were examined four times, the English Rostral patients only twice; nevertheless the English patients showed the greater change.

a. ii. *Convexity operations carried out for the treatment of intractable pain.* (Areas 9 and 10.)

The changes in ten patients who underwent a convexity operation for the relief of intractable pain were examined separately.

Approximately two months after the operation the clinical condition of four of these patients was considered to be greatly improved. There was some improvement in five more, whilst there was no change in the condition of one of the patients.

On all ten personality variables the pain patients showed changes in the predicted direction. This is highly significant according to the Binomial test (less than .01). Two of the test changes were significant when taken on their own; these were the decrease in suggestibility and in perseveration.

On the intellectual tests there was greater improvement on the Performance scale than on the Verbal scale. The total improvement on the complete Wechsler reached the level of significance. There were also higher scores on Porteus Mazes.

It would thus appear that patients with convexity operations for the relief of intractable pain show the same pattern of changes as that found in neurotics with the same lesions. Perhaps this provides some evidence in favour of the changes described being the basic pattern in man when the frontal lobes are no longer intact. It enables us, in any case, to argue from the effect of these operations on neurotic patients, as to what may be happening to patients suffering from intractable pain after these lesions.

a. iii. *Convexity operations with lesions in Brodmann's area 10.*

The changes in nine patients using the convexity operation involving area 10 only were examined separately. It was found that all ten variables were changed in the predicted direction and that the changes were highly significant according to the Binomial test. (Probability less than .01.) Four individual test changes reached the level of significance when taken on their own. These were decreased suggestibility, increased speed of writing, decreased perseveration, and increased speed in a series of trials at a task of manual dexterity. It is worth noting that three out of these four changes are on variables related to "neuroticism," whilst only one is related to increased "extraversion." This fits in well with Le Beau's observation suggesting that area 9 as opposed to 10 appears to be mainly responsible for the increased extraverted behaviour of the patients. With a sample of this size we can, however, only point to the suggestive nature of these findings.

b. *Anterior Cingulectomy.* (Area 24.)

Ten patients were subjected to anterior cingulectomy. This primarily involves area 24 and does *not* affect the granular cortex. On the five variables related to "neuroticism" the changes were inconsistent and the picture unclear; on two variables they were in different directions on the third and fourth re-test. One change increased significantly; this was the top score of a series of trials in a test of manual dexterity.

With regard to the five variables related to diminished "introversion" four changes were in the *opposite* direction to that of all the convexity operations. One of these—the *decrease* in the number of mistakes on a series of trials of manual dexterity—was highly significant.

A significant *improvement* in Verbal I.Q. was found after cingulectomy. This is another difference between its effects and that of lesions in the convexity.

It will be noted that the whole pattern of change is atypical in comparison with that after all the convexity operations. The most noticeable difference, however, is that there is *no* indication of increased extraversion. This fits in well with the clinical impressions reported above.

Owing to the smallness of the group, there can be no certainty that it constitutes a representative sample of a larger population; the findings must, therefore, be regarded as not necessarily conclusive. It is, nevertheless, surprising that after having had consistent pattern of changes with four small groups who had undergone convexity operations in France, and four groups with different convexity operations in England (Petrie, 1952*b*), the cingulectomy group should be an exception. It may well be that these results are, therefore, a pointer that the changes found after lesions in the prefrontal cortex are specific to this area.

c. *Mesial Undercutting*. (Brodmann's Areas 9, 10, 24 and 32.)

This is an operation involving both the convexity and the anterior cingulate. Hence one would expect the changes to be a combination of the effect of the convexity and cingulectomy operation. This was confirmed by our impression of the six patients operated by this technique. The pattern was suggestive of an effect midway between the clear alterations following on a pre-frontal lesion and the somewhat contradictory and inconsistent changes after cingulectomy.

DISCUSSION.

The results of all the different convexity operations indicate the consistency of the pattern of changes caused by these incisions, and the agreement of this pattern with that in the patients previously examined in England. As was suggested after comparing the operations in England, the extent of the operation appears to be directly related to the extent of change—the least extensive operation causing least change (Petrie, 1952*b*). Perhaps of even greater importance is the confirmation that the same pattern of changes occurs after convexity operations performed for the relief of intractable pain as after those carried out for the treatment of severe neuroticism.

All these convexity operations result in changes on five variables in the direction of a decrease in the factor of "neuroticism" and on five variables in the direction of a decrease in the factor of "introversion," so that such a patient is less suggestible, less self-critical, less perseverating in motor tasks, and his top score in a series of trials at a test of manual dexterity has improved. He shows a tendency to blame the environment rather than himself; a pre-occupation with the present rather than the past—or the future; an increased liking for sex humour; a preference for speed rather than for accuracy; and a decrease in the ratio of his verbal to performance intelligence.

The results have also confirmed that when the operation is limited primarily to Brodmann's areas 9 and 10, the loss on tests of intelligence—present after a more extensive operation, such as the Standard (Petrie, 1952*b*) fail to occur. The alterations in personality of the cingulectomy patients are suggestive that these changes are specific to lesions in the pre-frontal region—or, more precisely, in the granular cortex; for although the same pattern of changes appears after seven different types of pre-frontal operation, a different picture is presented after cingulectomy. These findings are supported by clinical impressions based on many more patients. The cingulectomy cases do behave differently from the others. This is not surprising as the granular cortex is an entity, and if it is not involved one would expect to find different effects on personality. It is also noteworthy that this is probably one of the first occasions in which the lateral areas have not been involved in such an operation, and that cingulectomy affects a smaller area than most other frontal operations.

It is, however, necessary to point out that the group of cingulate patients differed from the other patients on two variables besides the type of incision. The majority were epileptics and they were of lower intelligence than the others. We have no reason to believe from the previous work carried out with epileptics that they would respond differently from other patients to the personality tests included in this battery (Davies Eysenck, 1950 and 1952). Their average score lies somewhere between that of a neurotic and a normal population. It is difficult to estimate to what extent their low intelligence may be influencing the results. It is interesting, however, to note that there is a relationship between the clinical impression of the convexity operation causing increased extraversion—which is not the case after cingulectomy—and our findings on objective tests that there is a clear-cut change towards the extraverted end of the scale after convexity operations, but not after cingulectomy.

The changes found at the third investigation have been reported after all the convexity operations. These results were supported by the fourth re-test, although this has only been carried out to date on some of the patients. Only in the case of the cingulectomy patients did the third and fourth re-test changes appear to go in opposite directions, thus adding to the atypical pattern after this operation.

The second investigation—that is the first post-operative—carried out from one to four weeks after the operation, did not present consistent results in any of the groups. On more than half the variables the change appeared to go in the opposite

direction to that which it showed later. We are presumably measuring the effect of the traumatic shock of the lesion in addition to the deficit the lesion has caused. This may be a hint that the original effect of the deficit is not consistent; what is consistent is the adaptation made to it. It has been reported that—from the clinical viewpoint—the immediate post-operative syndrome seems to bear no relationship to the long-term therapeutic results (Le Beau, 1951).

A detailed clinical study of intractable pain patients has demonstrated that a great improvement in their condition after the operation is compatible with very good social adjustment (Gaches, 1952). The circumscribed incisions carried out on these patients have now also been shown—on objective tests—to be followed by the least change of all the operations so far studied. With regard to the identity of the pattern of changes in the intractable pain patients and the neurotic patients it will be realized that some of the pain cases may, in fact, have been neurotic. Nevertheless, the personality change has caused an alteration in their attitude towards pain; and the nature of this change in personality is predictable from our findings on neurotics.

Numerous researches have demonstrated that whilst leucotomy can alleviate the condition of patients suffering from intractable pain—as is reported in this paper—it does not achieve this result by raising the threshold to pain sensitivity (Chapman *et al.*, 1948; Fleming, 1950). In a recent publication it was suggested that some of the objective changes in personality found in neurotic patients after leucotomy may be contributory factors to the effect of this operation on pain patients (Petrie, 1952*b*). The point was made that the patient's increased orientation to the present, as opposed to the past and future, and his reports indicating that time was passing more quickly after the operation, might be related to the change in his attitude to pain.

If as a result of the change in attitude to time the patient is less concerned with the pain that may be coming and the pain that has passed, he is primarily contending with the present pain on its own. It is not possible to estimate how much this shrinkage in the range of interests in time makes the total situation more bearable; but it appears reasonable to suggest that it may be contributing to this effect. It is tempting to speculate whether the effect of the change in the patient's estimate of the passage of time is the obverse of that in a situation in which time appears to be passing more slowly than usual. In the ten minutes between the alarm clock ringing and the arrival of the early morning cup of tea, time can be subjectively stretched to contain a dream covering 24 hours of agony and fear. To many of us such a dream day may be more unpleasant than ten minutes of actual agony and fear. When time, instead of being stretched, contracts as it seems to do after frontal lobe lesions, the contrary might be true. To some extent the suffering might become more bearable. In any case, the pain patients in this series showed changes in these directions: they were more orientated to the present, and their estimate of time changed in a manner suggesting that time was passing more quickly for them.*

In addition to these two changes, it is noteworthy that after operations which are successful in such cases, the patients show a pronounced decrease in suggestibility. If an individual becomes, for example, less suggestible to the idea that an article he is touching is hot, he might perhaps be less suggestible also to the idea that a sensation he is feeling is painful. It is not suggested that these objective changes are anything but contributory to the effect of this operation on patients with intractable pain. It would, however, seem desirable to explore further the impact of this type of change on attitude to a painful situation.

SUMMARY.

1. Various selective frontal operations carried out in France are described. These include convexity incisions (Brodmann's area 9 and 10) and cingulectomy (areas 24 and 32).
2. Brief reports of therapeutic results with different groups of patients are presented.

* Investigations as to increased distractibility and less vivid imagery have not, as yet, been carried out on patients suffering from intractable pain. It was, therefore, not possible to obtain evidence in support of the suggestion that such changes—found in neurotic patients after these operations—were also related to the alteration in pain attitude (Petrie, 1952*b*).

3. 34 of the patients were examined on a group of objective psychological tests before and on three separate occasions after the operations.

4. The pattern of changes in temperament and character found in 17 patients who had undergone selective convexity operations is the same as that found in patients after leucotomies carried out in England. The changes indicate a decrease on five variables related to "neuroticism" and a decrease on five variables related to "introversion."

5. The extent of the changes was less after the French operation than after the English operation. The former are also more circumscribed.

6. The loss on intellectual tests found after the Standard operation in England was not present following on the circumscribed operations in France.

7. The pattern of changes on the ten variables was the same in patients operated on for the relief of intractable pain as in those operated for the treatment of mental illness.

8. Whilst the same pattern of changes on the ten variables occurred after all the convexity operations involving the granular cortex, a different pattern emerged after anterior cingulectomy involving the cingulate area. This, in combination with the clinical effects of cingulectomy, provides suggestive evidence that the changes found after the convexity operations are specific to the granular cortex of the pre-frontal areas.

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