PREFRONTAL LEUCOTOMY.

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THE operation of prefrontal leucotomy or, as some call it, prefrontal lobotomy, is one of the most startling of modern therapeutic procedures. It was introduced in Portugal by Moniz (1936)—the actual operation being performed by Lima—and was subsequently developed in Italy and in America. In this country it was first carried out at the Burden Neurological Institute in Bristol on December 11, 1940. At the time of writing (May, 1943) some 350 leucotomies have been performed in Great Britain. In 1942 Freeman published his book, *Psychosurgery*, dealing with the work done up to the end of 1941. Most of the work dealt with in the present review has been published since then, although for the sake of completeness Freeman's book will be referred to.

There has been little reference to prefrontal leucotomy in any available German or Italian literature since the beginning of the war, but it is quite possible that papers on the subject have appeared on the Continent and have not been available to American and British abstractors. There has been some hostile criticism of the operation by medical men with no experience of it and little experience of psychiatry. Time alone can tell whether the initial success is going to be developed until the operation is accepted as an essential part of our therapeutic equipment. It seems a pity that such a technical matter as a prefrontal leucotomy should be discussed in the lay press, and we can only deprecate very strongly the action of medical men who have encouraged this.

EXPERIMENTAL WORK.

The frontal lobe is considered to be one of man's most precious and most peculiar structural endowments. It serves to distinguish him from the great apes. The development of the prefrontal lobes is associated with the more intellectual types of man, and yet we have the suggestion made that they be surgically mutilated or severed from the rest of the brain in an attempt to cure a mental illness, sometimes of long standing.

Golla (1943) points out that the static view of the central nervous system has to be abandoned and a more labile conception adopted. If the brain is damaged and cannot work in one way it will re-orientate itself and work in another. In some cases the brain by a circuitous route will perform the same functions, possibly not quite so well, but possibly also in some cases even rather better than before. Golla points out that if irreparable damage has not been done to the brain before operation, the patient may learn to use other mechanisms for his mental operation and may use them every bit as well.

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The tracts which theoretically should be divided by the section of the white matter are (Fulton, 1938) the *corticothalamic* system connecting the dorsal medial nucleus of the thalamus with the cortex, the *prefrontopontine* system (generally known as Arnold's bundle; and in the macaca monkey coming from areas 9 and 10 and terminating in the substantia nigra and dorsomedial pontine nuclei), the *corticomesencephalic* tract—a compact bundle of fibres rising in the prefrontal region in the same area as Arnold's bundle and passing along the medial tip of the cerebral peduncle—and the *corticostriate* system, which passes from the prefrontal area to the globus pallidus. In addition to these named fibre systems there are other association systems passing to other areas of the cortex.

The rationale of the operation of prefrontal leucotomy is based chiefly on severing the fibres connecting the prefrontal cortex with the dorsomedial nucleus of the thalamus. Earl Walker (1940) gives a very good account of this nucleus. He points out that various workers have shown the existence of fibres passing both from the prefrontal cortex to the dorsomedial nucleus and vice versa. Degeneration in this nucleus has been found by many investigators after lesions of the prefrontal cortex (see " Pathology," p. 498).

In the macaca monkey Walker found that the dorsomedial nucleus projects to the greater part of the prefrontal cortex on the lateral and inferior surfaces of the frontal lobe. The medial part of the dorsomedial nucleus which is related to the hypothalamic structures sends its fibres to the orbital surface of the frontal lobe, which is a cortical centre for the vagus nerve (Bailey and Bremer, 1938). The lateral parts of the nucleus project to the cortex of the convexity of the frontal lobe. Earl Walker points out that lesions of the medial thalamic nucleus made by himself and Jacobsen in several macaca monkeys trained in various psychological tests, produced no apparent change in the animals' behaviour and no impairment of their ability to perform delayed reaction tests.

Earl Walker (1938) points out that the neothalamic portion of the nucleus medialis dorsalis sends its fibres to the granular region, more particularly to area 9. There is a spatial organization in this projection; an antero-posterior plane in the nucleus projects to each point of the prefrontal cortex. The radiation is arranged in laminar fashion, for the paralamellar part of the nucleus projects to the cortex along the inferior precentral sulcus—the inferior portion medially and the superior part laterally. The medial and dorsal parts of the nucleus send their fibres to the dorsal and anterior parts of the granular frontal cortex. There is a certain antero-posterior relationship in the projection, for the anterior parts of the nucleus project to the cortical areas slightly more anteriorly than the posterior parts of the nucleus. The fact that a plane rather than a point in the nucleus projects to each point in the prefrontal granular cortex allows ample opportunity for complex integrations to be made at both the thalamic and cortical levels. Walker also points out that in lesions of the frontal lobe in man, primates and even carnivora, there is at least one common defect, one of association. In monkeys it is best demonstrated as a defect of reproductive memory; in man it manifests itself as an inability to synthesize the problems or situations of the external

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world. It is possible that the nucleus medialis dorsalis serves as an integrating centre for somatic sensory and visceral impulses, presenting them to the cortex of the prefrontal region in a complex form. He points out that it is unlikely that association with the auditory and visual systems is made through this nucleus, but well-known association tracts, the occipito- and temporo-frontal tracts connect the cortical centres of these systems with the prefrontal cortex, and by means of these tracts such associations can readily occur. If such were the sole connections of this nucleus, its main contribution would be the integration of elaborated afferent somatic sensory and visceral impulses and their projection to the cerebral cortex, not as sensory modalities, but as sensory concepts.

Strasburger (1941) points out that different cortical fields have special functions, but it is not easy to define them accurately. We know almost nothing of the role of the specialized cortical cells or the layers in the total performance, and nothing of the nature of engrams or the substrata of perception and ideas.

Goldby (1943) found in his work on the phalanger thalamus that in three cases, when the prefrontal area was damaged, there was severe degeneration of the dorso-medial nucleus. In the two instances where this was most pronounced, there was complete degeneration of the lateral small-celled part of the nucleus, occupying about a third of the transverse area of the whole nucleus anteriorly, and about a half posteriorly. The area of this nucleus which lacks corticopetal connections is large in the phalanger, but is reduced to a very small area in man (Le Gros Clark and Russell, 1940).

Richter and Hawkes (1939) found that removal of the frontal poles of the brain in the rat gave rise to greatly increased activity together with greatly increased food intake.

Waller (1940), from experiments on cats, found degeneration in the medial nucleus of the thalamus after lesions in the frontal lobes involving the gyrus proreus. The lateral part of the medial nucleus is connected to the upper part of the frontal granular area (Brodmann and others). The medial part sends its fibres to the lower granular cortex.

Warden, Barrera and Galt (1942) found in three monkeys that unilateral ablation of the frontal lobe had no effect on the retention of either simple or complex visual discrimination problems. When both frontal poles were injured simple discrimination was lost and only re-learned with difficulty. Complex discrimination was lost and could not be re-learned even after a thousand trials. Memory function appears to be concerned in all these types of problem. Unilateral ablation had no effect on the retention of the single platform instrumentation habit. The more complex stages of the double and triple platform habits were disturbed. Bilateral injury has no effect on the single platform habit, but the triple platform habit was entirely lost. No recovery of function was shown after retesting multiple platform instrumentation five weeks after bilateral injury. All the animals showed a general decrease in emotional tone during the tests after bilateral ablation. Rage and baring of teeth when frustrated entirely disappeared after operation. In some monkeys "neurotic" reactions occurred after unilateral ablation, e.g.

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rolling about the floor, biting hands and feet, pulling out hair, displaying facial contortion; these symptoms never occurred after bilateral ablation. Bilateral ablation also was instrumental in changing the degree of dominance in some pairs of monkeys.

Harlow and Dagnon (1943) found that monkeys after bilateral prefrontal leucotomy made more errors than normal monkeys in learning both a series of discrimination problems and a series of discrimination-reversals. They considered that these results were due either to a general decrease in ability to adapt to new situations, or to a loss within some more specific function which acts to facilitate discrimination learning and reversal. These authors also found that additional training reduced the number of errors.

Spaet and Harlow (1943) found in two rhesus monkeys that after bilateral removal of the prefrontal areas, the animals were able to respond successfully to delayed reaction problems tested by means of a matching from sample technique, but there was undoubted impairment which might result from loss of speed in learning, loss of effectiveness of " expected " reward and difficulty in reversing symbolic associations.

Malmo and Kleinfasser (1942), as a result of their experiments on monkeys, in which they had removed the frontal association areas on both sides, suggest the hypothesis that removal of the frontal association areas in primates leads to a marked impairment of their general capacities for memory, because the loss of these areas renders them more susceptible to retroactive inhibition.

Harlow and Johnson (1943) found in two rhesus monkeys, after bilateral destruction of the prefrontal areas, a deficit in response to a simple problem which does not involve the formation of any new association, or the utilization of any principle or symbolic process.

Shenkin and Ruch (1943) point out that bilateral ablation of area 13 on the orbital surface of the cerebral cortex in monkeys produced many of the symptoms which have been described following prefrontal lobectomy. They found hyperactivity consistently obtained, but other motor activities which were not marked by hyperactivity suffered reduction. Random spontaneous activities and posturings were reduced in variety and in quantity, as was emotional expressiveness. There were also certain ill-defined behaviour changes. Hyperactivity was accompanied by loss in weight and a slight increase in food intake. The monkeys do not react to the presence of visitors as do other monkeys; they show no fear. In man, area 13 is far back towards the olfactory striae and is probably not affected by prefrontal leucotomy.

Finan (1942) found in monkeys that when the frontal association areas on both sides were ablated, there was a complete loss of the delayed response. When the delayed response was made similar to discriminative learning by reinforcing the presentation trials, the response was partially reinstated.

Smith (1942), in experiments on cats, found after ablation of the frontal lobes considerable hyperactivity. These cats showed forced following-responses to visual stimuli. The hyperactivity involves in part at least the modification of the inhibitory mechanisms of control of visual orientation.

Epstein and Morgan (1943) conclude from their experiments on rats which had had their prefrontal areas removed, that the fractional goal reaction in

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maze behaviour involves symbolic processes which are mediated by the prefrontal cortical areas.

Morgan and Wood (1943) found from experiments on rat brains that animals with bilateral prefrontal lesions lost their ability to use recent memory. From this they conclude that in the rat there is a prefrontal association area for recent memory, or possibly " an ability to maintain a set in the face of distraction."

Indications and Contra-indications.

In what is to a certain extent an experimental procedure and certainly a surgical treatment in its early development, it is not easy to lay down any rigid rules as to what types of case are most suitable for operation.

Freeman and Watts' (1943) opinion is worth quoting: " The individual who is ideally suited for prefrontal lobotomy is one whose emotions are largely concerned with himself. This is the patient who fears heart disease or cancer or syphilis or contamination; who is a prey to ideas of guilt or of persecution, who broods excessively on the terrors of the unknown future and who cannot make up his mind between this and that; who gets so emotionally disturbed on coming in contact with others that he is unable to think clearly; who sees death as the only solution to his difficulties. More difficult to influence satisfactorily are those persons who have drifted away from the world of reality, and who are constantly harassed by imaginary voices, visions, odours and by fixed ideas that keep coming again and again. Nevertheless, as long as there is a certain minimum of emotion that attaches itself to the ideas, a good result in terms of relief from distress can be anticipated. Only when the emotion dies out and the individual lapses completely into the dream world of psychosis with no struggle against the manifestations of disease, is he to be considered too emotionally deteriorated to be aided by psychosurgery."

The results published so far divide themselves into two groups, one in which the operation has been performed on chronic cases merely in the hope of making them easier to nurse, and the other in which the operation has been performed with the definite aim of curing the patient.

In the first group are found very largely the hostile, noisy and destructive catatonic types of schizophrenia, whether of long standing or not, and whether demented or not (Dax, 1943; Ström-Olsen, 1943; Rees, 1943; Cook, 1943; Carse, 1943).

The second group can be divided into (*a*) all types of mental illness when depression is the prominent feature, and (*b*) obsessional cases often very long-standing and chronic, where anxiety is the chief symptom (Hutton, Fleming and Fox, 1941; Fleming, 1942; Hutton, 1943; Fleming and McKissock, 1943).

With regard to the second group there is considerable difference of opinion as to when operation should be performed.

Rees (1943) considers that the indications for prefrontal leucotomy are functional mental disorders with symptoms of active conflict which have failed to respond to other methods of treatment, and where the prospects of spontaneous recovery are remote.

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Ström-Olsen, Last and Brody (1943) state that they are of the opinion that prefrontal leucotomy is of benefit in the chronic type of psychotic patient described in this paper, but in view of the risk of producing undesirable new symptoms, both mental and physical, the operation should only be undertaken when all other methods of treatment have failed, and where it can reasonably be assumed that the chances of remission or recovery are very remote.

Fleming (1943) considers that leucotomy may well be performed at an early stage without any previous treatment.

Cook (1943) considers it wise to confine the operation to those who have not responded to other forms of treatment, or who have been in a state of mental disorder for some time.

Banay and Davidoff (1942) performed a leucotomy on a sex psychopath who, six months after operation, showed a perfact adjustment to his environment. His state of agitation, emotional panic and diffuse sympathetic discharges disappeared, as well as the elaborate sexual fantasies. There was no intellectual impairment. The authors consider that persons over fifty years of age, whose pathological sexual desires are increasing with their declining years, and whose history consists of persistent criminal sex offence of obsession-compulsion type, accompanied by marked agitation or other emotional disorganization, appear to be suitable cases for leucotomy.

The *contra-indications* have received little attention in the papers published. They are more a matter for the neurological surgeons to deal with. Generally speaking, they consist in the usual contra-indications to surgical operation. A high systolic blood pressure and a diastolic of over 100 mm. Hg are regarded as dangerous (McKissock, 1943*b*).

Freeman (1942), on the other hand, states that he has operated on patients with a diastolic of 110 mm. Hg and even 128 without any evil effects.

Willway (1943) does not regard age *per se* as a contra-indication, having operated on three people over seventy. He has operated on hypertensives without any post-operative worries.

Lima (1943) reports that in Portugal the operation is performed chiefly on involutional psychoses and obsessives. Their results with schizophrenics were poor, but only very old cases which had already had insulin and cardiazol were operated on. Flores, in Lisbon, only has the operation done after convulsion treatment has failed.

To sum up, the present opinion amongst those best qualified to judge appears to be that almost any mental illness of long-standing duration, apart from chronic mania, epilepsy and general paralysis, is worthy of serious consideration for operation. Amongst recent cases, those which have proved resistant to electric shock treatment should be considered for operation.

Technique.

No two neurosurgeons appear to use quite the same method. The approach is the same for all, and after entering the dura is, of course, " blind " unless Lyerly's method of open operation is used. As far as I know the open method has not been used in this country. Lyerly (1942) cuts out a small window in

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the skull and is able to see exactly what he is dividing, and so control haemorrhage rather better. It must be admitted, however, that his results are no better than by using the quicker blind approach. For details of technique, which are beyond the scope of a short review, the papers of Ström-Olsen, Last, Brody and Knight (1943), Dax (1943), Willway (1943), McKissock (1943) and Freeman's *Psychosurgery* must be referred to. It would appear that the section has to be made almost immediately in front of the anterior end of the lateral ventricle. The ventricle, of course, must not be entered. Sections made too far forward do not appear to yield such good results.

There is considerable difference of opinion as to the instrument most suited for dividing the white matter. Crombie (1941) has invented a leucotome which cuts through an arc, Willway uses a narrow paper knife, and McKissock a blunt brain needle. The whole object, of course, is to divide the white matter without tearing or dividing any vessels.

McKissock (1943*c*) has devised a modified operation. In dealing with certain chronic obsessional states, where the underlying personality was of good quality and it was highly desirable to avoid deterioration after operation, a modified leucotomy was performed with the idea that, if this failed to produce an adequate therapeutic result, a more extensive section could be carried out at a later date.

In a small series of such cases section only of the lowermost fibres was performed; no deterioration was produced, but the therapeutic effect was adequate in the opinion of the psychiatrists concerned.

This modified operation is carried out by introducing the brain needle at a point 3 cm. behind the lateral margin of the orbit and 6 cm. above the zygoma. The needle is directed inwards and slightly forwards to reach a point about 1 cm. lateral to the falx but in front of the tip of the ventricle and in the horizontal plane of the base of the anterior fossa. The point of the needle is made to travel downwards towards the base of the skull, keeping parallel with the falx by introducing the instrument a little more deeply, and thence across the anterior fossa to the lateral margin, withdrawing the needle in the process in order to avoid striking the grey matter and the sulci of the inferior surface of the frontal pole. No section of the fibres lying above the point of entry of the needle is made.

Seizures.

From the nature of the operation it was to be expected that consequent on the formation of scar tissue seizures might be expected to develop.

Goldstein (1942), in discussing the occurrence of epilepsy after penetrating wounds of the head, points out that between 15–20 per cent. suffer from motor epilepsy. Most of the epileptic attacks occur in the first two years after injury, but there was no evidence that individuals who have early attacks necessarily suffer later from epilepsy. The late attacks are usually due to scar formation. He found that 50 per cent. of all patients who had attacks in the first week of injury did not acquire permanent epilepsy. After head injuries epilepsy is most frequent after lesions in the parietal region, but lesions of the frontal lobe can also produce epilepsy usually of a more tonic character.

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None of the observers of seizures following on leucotomy report as to the nature of the attacks, nor do they as a rule report how soon after the operation.

Freeman (1942) in his book quotes Lyerly as having three instances of seizures in 44 cases of leucotomy performed by the open method. Freeman himself thinks that about 4 per cent. have seizures, most of these being in cases operated on by the superior approach, which appears to bring the cortical incision dangerously near the motor centres. He expresses the opinion that the smaller the incision through the cortex the less the likelihood of a focus arising subsequently. Freeman gives 15 instances in 150 patients, but not all were persistent; some have gone more than two years without another attack.

McKissock (1943) found four patients out of 50 had a seizure. Radley Smith (1943) found one patient with a seizure out of 62 cases operated on; Ström-Olsen (1943) one out of 30; Hutton one out of 50.

	Cases.	Instances of seizures.	Percentage with seizures.
Freeman	150	15	10
McKissock	50	4	8
Lyerly	44	3	7
Radley-Smith	62	1	1·6
Ström-Olsen	30	1	3·3
Hutton	50	1	2
Total	386	25	6·4

Goldstein very wisely points out the necessity of attending to the conditions under which patients live after head injuries, and these remarks may with advantage be applied to the prefrontal leucotomy cases. He considers as conditions to be avoided: the use of alcohol even in small doses, physical over-exertion, jarring in car or train, exposure to sun and irritations of any kind —mental as well as physical.

Incontinence.

Goldstein (1942) found in some cases where a projectile had damaged the frontal lobes at high speed that the patients lie down more or less motionless, but have no control of either bladder or rectum. These cases may improve after a few weeks. Freeman (1942) states that urinary incontinence is quite a common condition in the days following operation, but that it rarely lasts longer than two weeks. Rectal incontinence according to him is not so common. The patients seem to be mostly quite unconcerned about it. Fleming and McKissock (1943) state that one-third of their cases were wet. Only one out of the 15 cases was wet after the first month, and this case was quite unconcerned about it, although she had made a complete recovery mentally. They have the impression that the more severely affected mentally the patient is, the more likely is he to be wet after leucotomy. Ström-Olsen, Last and Brody (1943) found one-third of their cases with incontinence; half of these were only temporarily so.

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Psychological Changes.

Before considering the mental changes after leucotomy it is well to consider sundry findings reported by Goldstein (1942) in his book. He reports that he has seen men who, after a short period of unconsciousness, have stood up and walked a considerable distance with no symptoms other than headache after a high-velocity bullet had passed through both frontal lobes. He found that some cases with lesions of both frontal lobes showed a picture of a katatonia-like stupor. Frequently compulsive crying and laughing are observed in patients with frontal lobe lesions. His condition of homolateral hyporeflexia has not so far been reported after leucotomy, but is worth watching for. He describes disturbance of tonus and equilibrium occurring even years after injury. These consist of abnormal postures, involuntary deviations, startle phenomena, sensory errors, etc., and occur especially when the premotor area has been damaged. In the mental sphere he found an impairment in the capacity for abstraction, i.e. they become more concrete in their behaviour. He found faces usually rigid, lacking expressive movements, the patients slow and dull. He describes a " catastrophic situation "—this consists in a reaction to a simple problem, which the patient is unable to solve. He becomes agitated, looks dazed, starts to fumble, his pulse becomes irregular, he is sullen, evasive, and may even become aggressive. His patients avoided company; readjustment to any new situation was difficult. Another symptom he found was an excessive orderliness, probably to diminish the amount of effort required to lay hands on any object.

Goldstein describes a disturbance of the relation between figure and ground, the sharp differentiation of figure from background suffers, the two intermingling, and there may even be an inversion, figure becoming background and background figure.

He emphasizes the impairment of the attitude toward the abstract. The abstract attitude depends on assuming a mental set voluntarily; shifting from one aspect of a situation to another, making a choice; keeping in mind simultaneously various aspects of a situation; grasping the essential of a given whole, breaking up a given whole into parts and isolating them voluntarily, abstracting common properties, planning ahead intentionally, thinking or performing symbolically and detaching the ego from the outer world. Fleming (1943) found in a man, aged 62, who had a high conceptual quotient of Shipley-Hartford, both before and after his leucotomy, that he failed very badly on the progressive matrices, which may be regarded as a good non-verbal test of abstract reasoning.

Freeman (1942) sums up his findings very well. He points out that the person whose frontal association areas have been partially inactivated by prefrontal lobotomy presents a number of peculiarities that distinguish him from his pre-operative self. He is freed from anxiety and from feelings of inferiority; he loses interest in himself, both as to his body and as to his relationship with his environment, no longer caring whether his heart beats or his stomach churns, or whether his remarks embarrass his associates. His interests turn outwards and obsessive thinking is abolished. He responds immediately and sometimes vividly to external impressions, showing something of an

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emotional incontinence that makes for ready laughter or petulance. The emotional responses may be vivid, but they are lacking in depth and quickly evaporate. His mood is, on the whole, elevated, and the extraversion and ready response make for an apparently quick-witted enthusiastic individual who gets along superficially with everybody. There is something childish in the cheerful and unselfconscious behaviour of the operated patient. The intellectual equipment, in the sense of past experience, is undamaged, but close examination discloses certain defects that become more obvious in the case of extensive incisions. These intellectual defects immediately following operation consist in a certain rigidity in categorical attitude, in an inability to find new or different methods of solution for difficult problems, an inability to retain in consciousness simultaneously a number of concepts presented simultaneously; a disturbance of the temporal patterning of activity; a certain lack of ability to synthesize and to arrive at a correct solution after considering all the factors involved. In the ensuing months these defects become diminished or disappear completely. There is, however, an apparent inability to foresee accurately the results of a series of planned acts as they relate to the individual himself. There is a very distinct difference in the behaviour of the individual in the immediate post-operative phase and that which appears later on, when the patient has arrived at a stationary condition. The patient often behaves very much better before strangers than before his own relatives—they seem almost to enjoy offending their relatives for a while.

Hunt (1942), in Freeman's book, gives a good account of her studies on the Rorschach test before and after leucotomy. She found a more restricted and constricted personality with less variety and individuality of response. Form responses (F) were practically the same after as before; movement responses (M) were low both before and after. There was a slight increase of animal movement (FM) responses after operation. The ratio of movement to colour responses (M : ΣC) was significantly increased; this may mean a change in the direction of greater cheerfulness. There was a decrease in the total number of responses (R) after operation, and an increase in the number of D responses, which signifies a move towards normality. There was a noticeable increase of apathy towards the test. All these results were obtained soon after the operation. On six patients tested at longer intervals after the operation the author found general expansion, greater indication of intellectual adequacy and fewer indications of abnormality. There was an increase in total responses, better distribution of W, D, d and S responses, more movement responses, better proportion of good F responses and a more normal number and distribution of colour type responses. Hutton (1943) is able to confirm most of these findings.

Ström-Olsen *et al.* (1943), basing their opinion on psychometric investigations, point out that a considerable proportion of the schizophrenics cannot be properly tested. Among those who were tested it was obvious that lethargy, lack of spontaneity and an attitude of suspicion interfered with the results. After making these allowances they found that nine out of ten showed no defects after the operation. There was no relation between test performance and the appearance of an abnormal EEG. The battery of tests they used were :

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Terman Vocabulary, Revised Stanford-Binet, the " Discrepancy Test " modification of Babcock's scale, Kohs Blocks, Porteus Mazes, the Passalong Test, Progressive Matrices and the Shipley-Hartford. Brody and Hutton (1942) have prepared a battery of tests for use before and after leucotomy. This battery contains eleven tests which require between 25–40 minutes to administer; they consist of vocabulary, paragraph memory, Weigl, picture absurdities, cancellation, verbal absurdities, picture recognition, proverbs, recall, digits in all and sentences in all. The tests are administered before operation, and then six weeks, four months and one year after. Using the Shipley-Hartford Retreat Scale we have found no evidence of intellectual deterioration after leucotomy, although one patient who made a high score both before and after the operation did badly on the progressive matrices two months after operation.

Alford (1943) points out that the accepted characteristics of the frontal lobe syndrome consist of mental instability, a mild instability often too slight to give rise to confusion or complex formation. The disturbance in emotional control accounts for the change in character, the irresponsibility and impulsiveness and the elevations as well as the depressions of mood. There appears to be no indication that any part of the mental mechanism is lost with the removal of the frontal tissues.

Yacorzynski and Davis (1942) found in patients with unilateral lesions of the frontal lobes that the threshold of perception was raised, the number of objects perceived in ambiguous figures resembling the Rorschach test was decreased, visual illusions normally seen by everyone were either not perceived, or in the case of the Muller-Lyer illusion the illusion was exaggerated, memory for visually presented objects was decreased, and the reversals of figures with reversible perspectives, such as Rubin's figures, etc., were either absent or decreased. These authors suggest that the elation found in some patients with frontal lobe lesions may be due to the disturbed perceptual processes in which the ordinary inhibitory stimuli are no longer perceived as such.

Hebb (1941) found no significant alteration in the I.Q. after excisions of scar-tissue from the frontal lobe. He regards this as further evidence opposed to the localization of the Binet or performance test ability in the frontal association areas.

Re-education and Rehabilitation.

The re-education and rehabilitation of the prefrontal leucotomy patient is almost the most important part of the treatment. The patients are most suggestible and trainable, and for these reasons they should not leave hospital too soon. Their hospital period of convalescence should be prolonged.

Freeman and Watts (1943), in considering the convalescent care and rehabilitation of the leucotomy patient, point out that the patient is really an immature personality, and uses the trite expression for the immediately post-operative period of a " surgically induced childhood." This immaturity disappears as time passes, sometimes quite rapidly, but in some of Freeman and Watts'

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cases the process of social readaptation was not completed until for from three to five years after the operation. Out of a total of 170 cases operated on by Freeman and Watts (1943*b*) during the last six years, more than half are now usefully occupied. Of my own series of 35 cases during the past two and a half years, 26 have returned to their homes as resocialized and largely recovered individuals. These patients must be taken in hand firmly as soon as the immediate post-operative condition has settled down and given psychological treatment of various kinds, depending on the symptoms which have to be dealt with.

Results.

In estimating the value of the results quoted by the various writers, one has to remember that the cases chosen for operation by the British workers in particular have very largely been chronic cases of bad prognosis, cases which had failed to respond to any treatment. Fleming and Hutton are the only ones who have had leucotomies performed on patients who had had no previous treatment. The results of Carse (1943), who was able to discharge 10 out of 22 chronic schizophrenics, are most impressive.

(*a*) *Schizophrenia.*

	Cases.	Recovered or much improved.	Improved.	Not improved.
Hutton	32	9	14	10
Fleming	5	..	1	4
Dax	39	13	13	13
Rees	30	9	?	?
Ström-Olsen	11	2	4	5
Freeman	45	29	7	9
Carse	22	10	5	7
Total	184	72	44?	48?

(*b*) *Depressions.*

	Cases.	Recovered or much improved.	Improved.	Not improved.
Hutton	17	11	4	2
Fleming	19	16	1	2
Tarumianz	10	7	?	?
Dax	11	3	4	4
Lyerly	29	14	11	4
Ström-Olsen	7	2	1	4
Carse	1	1	..	..
Freeman	77	52	16	9
Total	171	106	37?	25?

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(*c*) *Other Psychoses.*

	Cases.	Recovered or much improved.	Improved.	Not improved.
Hutton	1	...	..	1
Fleming	6	6	..	..
Lyerly	9	2	3	4
Ström-Olsen	12	3	4	5
Carse	1	1	..	..
Freeman	48	29	12	7
Total	77	41	19	17

Pathology.

So far, apart from statements in Freeman's book, there has been no publication of a pathological investigation of material from a prefrontal leucotomy. Freeman reports investigations on three cases. In all three there was an isolated degeneration of the nucleus medialis dorsalis. In one case there was in addition degeneration of the cingulum and superior frontal gyrus; the degeneration in the thalamus spread to the nucleus antero-ventralis and possibly also to the nucleus ventralis lateralis. The large-cell portion of the nucleus medialis dorsalis was intact; this portion is supposed to connect to the hypothalamus rather than to the cerebral cortex.

In the degenerated portions there were few ganglion cells remaining, and these presented either swelling with pallor or shrinkage. There was an apparent increase in the number of small glia cells. There was present some dark staining material in the walls of the arteries of the globus pallidus. The cerebral cortex showed minor cellular change, apparently resulting from the terminal febrile state. There was local but very limited necrotic and reactive changes about the site of injury. No ganglion cells appeared to have disappeared; the lamination and polarity of the cells were satisfactorily maintained, and the cells presented no signs of axonal degeneration. There was no gliosis and no significant vascular change in spite of the relatively complete subcortical amputation of the frontal pole.

In one case there was a mild degeneration found in the anterior limb of the internal capsule by the Marchi method. The preservation of the nucleus antero-medialis in two of his cases he considers supports the idea that this nucleus projects on to the inferior surface of the frontal lobe, which was undamaged. Freeman also points out the importance of the degeneration and atrophy of the nucleus medialis dorsalis following leucotomy, in the alteration of the emotional life of the patient. He quotes a case reported by Stern (1939) in which there was apparently a primary atrophy of various thalamic nuclei, especially the nucleus medialis dorsalis on both sides, and in which the patient showed profound apathy, inertia and lack of emotional response for a long period preceding death. One case showed an extensive necrosis of the white matter except that lying under the gyrus rectus.

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Cortical Atrophy.

Dax (1943) reports three female agitated melancholics aged 35, 48 and 62 who had all failed to react to convulsions and who also failed to react to leucotomy. All showed shrunken frontal lobes. Alexander (1943) also reports having found marked cortical atrophy in schizophrenics at operation. They also had had convulsive therapy. The writer has had two cases, one of which recovered after leucotomy and did very well, but who had not had convulsive treatment, and one who had a severe cortical atrophy and did badly after both convulsive treatment and leucotomy. Another case of the writer's, a man, aged 62, had consistently resisted electro-shock even at 150 volts with repeated attempts and full duration. At operation the surgeon remarked that he had never operated on so " dry " a patient—there was practically no bleeding of any sort.

Mortality.

The death-rate is distinctly low. Freeman has had 4 deaths in 170 cases, Willway 2 in 90 cases, McKissock 3 in 120, Rees 2 in 30, Ström-Olsen 0 in 30, Dax 2 in 50 and Carse 2 in 27 ; a total of 15 deaths in 517 cases, a mortality-rate of 3·5 per cent. Of the 15 deaths, at least 9 were due to cerebral haemorrhage occurring within eight days of the operation.

References.

Alexander, G. L. (1943), *J. Ment. Sci.*, **89**, 187.
Alford, L. B. (1943), *Psychosom. Med.*, **5**, 15.
Bailey, P., and Bremer, F. (1938), *J. Neurophysiol.*, **1**, 405.
Banay R. S., and Davidoff, L. (1942), *J. Crim. Psychopath.*, **3**, 59.
Brody, M. B., and Hutton, E. L. (1942). Tests obtainable from The Secretary, R.M.P.A., 11, Chandos Street, Cavendish Square, London, W.1.
Carmichael, F. A. and F. A. jun. (1942), *J. Kansas Med. Soc.*, **43**, 200.
Carse, J. (1943), personal communication.
Cohen, L. H., Novick, R. G., and Ettleston, A. (1942), *Psychosom. Med.*, **4**, 96.
Cook, L. C. (1943), *J. Ment. Sci.*, **89**, 188.
Dax, E. C., and Radley Smith, E. J. (1943), *J. Ment. Sci.*, **89**, 182.
Drake, R. L., and Hibbard, J. S. (1942), *Kansas Med. Soc. J.*, **43**, 345.
Elfeld, P. F. (1942), *Delaware St. Med. J.*, **14**, 81.
Epstein, M. A., and Morgan, C. T. (1943), *J. Ex. Psychol.*, **32**, 453.
Finan, L. J. (1942), *Am. J. Psychol.*, **55**, 202.
Fleming, G. W. T. H. (1942), *J. Ment. Sci.*, **88**, 282.
Idem and McKissock, W. (1943), *Lancet*, i, 361.
Flothow, P. G., and Lemere, F. (1943), *West. J. Surg. Ob. Gyn.*, **51**, 1.
Freeman, W. (1942), *Psychosurgery*. Baltimore: C. J. Thomas.
Idem and Watts, J. W. (1942), *Dis. Nerv. Syst.*, **3**, 6.
Idem (1943*a*), *Am. J. Psychiat.*, **99**, 798.
Idem (1943*b*), personal communication.
Fulton, J. E. (1938), *The Physiology of the Nervous System*. London : Oxford University Press.
Goldby, F. (1943), *J. Anat.*, **77**, 195.
Goldstein, K. (1942), *After-effects of Brain Injuries in War*. London: Heinemann.
Golla, F. L. (1943), *J. Ment. Sci.*, **89**, 189.
Le Gros Clark, W. E., and Russell, D. S. (1940), *J. Neur. Psychiat.*, **3**, 123.
Harlow, H. F., and Dagnon, J. (1943), *J. Ex. Psychol.*, **32**, 351.
Harlow, H. F., and Johnson, T. (1943), *ibid.*, **32**, 495.
Hebb, D. O. (1941), *J. Gen. Psychol.*, **25**, 257.
Heilbrunn, G., and Hletko, P. (1943), *Am. J. Psychiat.*, **99**, 569.
Hunt, T. (1942), see Freeman's *Psychosurgery*, p. 164.
Hutton, E. L. (1942), *J. Ment. Sci.*, **88**, 275.
Idem (1943), personal communication.
Idem, Fleming, G. W. T. H., and Fox, F. E. (1941), *Lancet*, ii, 3.
Klopfer, B., and Miale, F. (1938), *Rorschach Res. Exch.*, **2**, 126.
Klopfer, B., and Tallman, G. (1938), *ibid.*, **3**, 31.

https://doi.org/10.1192/bjp.90.378.465 Published online by Cambridge University Press

LIMA, A. (1943), personal communication.
LYERLY, J. G. (1942), *J.A.M.A.*, **117**, 518.
MCKISSOCK, W. (1943*a*), *J. Ment. Sci.*, **89**, 194.
Idem (1943*b*), personal communication.
Idem (1943*c*), personal communication.
MALMO, R. B., and KLEINFASSER, A. J. (1942), *Psychol. Bull.*, **39**, 492.
MORGAN, C. T., and WOOD, W. M. (1943), *J. Neurophysiol.*, **6**, 173.
REES, T. P. (1943), *J. Ment. Sci.*, **89**, 161.
RICHTER, C. P., and HAWKES, C. D. (1939), *J. Neur. Psychiat.*, **2**, 231.
SHENKIN, D. A., and RUCH, T. C. (1943), *Arch. Neur. Psychiat.*, **49**, 780.
SMITH, K. O. (1942), *Psychol. Bull.*, **39**, 493.
SPART, T., and HARLOW, H. F. (1943), *J. Ex. Psychol.*, **32**, 424.
STERN, K. (1939), *Brain*, **62**, 157.
STRASBURGER, E. H. (1941), *Mschr. Psychiat. Neur.*, **104**, 78.
STRÖM-OLSEN, R., LAST, S. L., BRODY, M. B., and KNIGHT, G. C. (1943), *J. Ment. Sci.*, **89**, 1
TALLMAN, G., and KLOPFER, B. (1937), *Rorschach Res. Exch.*, **1**, 77.
TARUMIANZ (1941), *J.A.M.A.*, **117**, 517.
WALKER, A. E. (1938), *The Primate Thalamus*. Chicago.
Idem (1940), *J. Comp. Neur.*, **73**, 87.
WALLER, W. H. (1940), *ibid.*, **73**, 117.
WARDEN, C. J., BARRERA, C. E., and GALT, W. (1942), *J. Comp. Psychol.*, **34**, 149.
WATTS, J. W., and FREEMAN, W. (1942), *J. Internat. Coll. Surg.*, **5**, 233.
WILLWAY, F. W. (1943), *J. Ment. Sci.*, **89**, 192.
WYNEGAR, D. E. (1942), *Delaware St. Med. J.*, **14**, 96.
YACORZYNSKI, G. K., and DAVIS, L. (1942), *Psychol. Bull.*, **39**, 493.

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