

# FUNCTIONAL DISORGANIZATION OF THE LEFT LIMBS IN A TUMOUR OF THE CORPUS CALLOSUM INFILTRATING THE HEMISPHERES

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TUMOURS of the corpus callosum (C.c.) are known to be a difficult diagnostic problem. Intellectual and mental disturbances and rapid deterioration in the course of the illness have been observed in most of these cases and are considered by many authors to indicate an involvement of this body (Lévy-Valensi, 1910; Mingazzini, 1922; Ironside and Guttmacher, 1929; Alpers and Grant, 1931; Voris and Adson, 1935; Schlesinger, 1951, Bremer *et al.*, 1956). However, a similar picture may also occur in tumours of other sites; moreover, tumours of the C.c. tend to infiltrate the hemispheres, particularly the cingulum and the frontal lobes, and this might well account for the mental picture. A sign which seems to be more specific for damage of the C.c. is dyspraxia restricted to the left limbs in right-handed persons. Although this dyspraxia has been reported only in a small minority of cases concerned, it has not been observed in lesions other than those of the C.c.

Dyspraxia confined to the left limbs was also a noticeable sign in the case described here and its clinical value as indicative of damage of the C.c. was confirmed at post-mortem. However, a detailed study of the picture showed that dyspraxia was only one of many signs of the disorganization of the left limbs; there seemed therefore to be a problem of a wider issue, and this is the main subject of discussion in this paper.

## CLINICAL AND ANATOMICAL FINDINGS

The patient, Mrs. E.R. was first admitted to hospital in February, 1955 at the age of 61. She had been a school-teacher and had for the last 5 years been running a small hotel with her second husband. She was described as a bright and cheerful person, and a good mixer. A few months before she came to hospital she seemed to be depressed and became worried about her eyes. She was apprehensive and lacked confidence. When examined, there was no loss of intellectual function, and no pathological finding on physical examination. She presented the picture of a depression. The depressive signs improved considerably after treatment in hospital, and she was discharged in March of the same year.

She was re-admitted 6 months later in September, 1955.

On this occasion she showed no symptoms of depression, but had a suspicious attitude and suspected that her food might have been poisoned. In addition there were now definite signs of an organic cerebral process. On neurological examination there was a bilateral papilloedema; the right angle of mouth was lower than the left; otherwise the cranial nerves were intact. She had a mild paresis of her right limbs and dragged her right leg when walking. There was a marked ataxia on the right hand, and an astereognosis on the right. An accurate assessment of sensation was not possible, partly due to difficulties in holding her attention in these tests, partly due to the disorganized actions of her left hand. On the right fingers there was a defect in position sense. She could distinguish everywhere between touch and prick, but no reliable information could be obtained as regards localization of tactile stimuli, for reasons which will be described later. The deep reflexes were increased on the right and at the later stage in the illness a positive Babinski was found on the right. Her gait was somewhat unsteady. In Romberg the unsteadiness increased and she tended to fall to the left. At first there was no

visual defect on confrontation tests; later a definite left-sided homonymous hemianopia in the lower quadrant was found.

She showed a marked loss of memory, particularly for the recent past, and she could only vaguely recall more recent general happenings. Her attention for day to day happenings was considerably impaired. She was mentally quite alert. Information about her remote past was fairly adequate. She could give a satisfactory explanation of proverbs and gave adequate responses in similarity and difference tests. She could define correctly 37 words out of 45 in the Terman-Merrill vocabulary test. She had a quick grasp of pictorial situations such as depicted in Terman-Merrill, and in the T.A.T.

Her *attitude* towards her *illness* was usually one of neglect of her symptoms. On some occasions she would explain her difficulties such as her unsteadiness or weakness in her right arm or failure in writing or drawing, with her anxiety, insisting that it was a kind of psychological thing. On the other hand, she might state when she could not find the correct answer, that things were constantly disappearing from her mind as if they were blotted out.

The various specific functions were examined in a great number of sessions, and a film was taken of the actions of her hands; the following is a summary of these investigations:

Her *speech* was fluent without any mistakes; her *vocabulary* was very good and she could express herself well; there were no difficulties in *naming*. Her *spelling* was correct. *Reading* was fluent, and the *comprehension* of the written word was good. There was no disturbance in *visual recognition* of objects and pictorial situations. *Colour naming* and *sorting* were prompt. She did simple mental and written *arithmetic*, sometimes with slight mistakes, and more slowly than one would expect from a person who had been a teacher.

*Handling of Objects:* When asked to strike a match with her *left* hand, she opens the match box, then she shifts the matches about inside the box or puts one of the matches on top of the box; or she may hold the match in an awkward, inappropriate position, not knowing how to make the striking movements, or where to strike. She makes the correct movements immediately with the *right* hand. When asked to cut with scissors a sheet of paper into half with her *left* hand, she does not use the fingers appropriately for this action, does not get the scissors into the proper position, and will finally hold the closed scissors helplessly above the paper. She does it correctly with the *right* hand. When asked to turn, with the *left* hand, the wheel of a whisk, she is uncertain how to approach it, and finally turns the knob instead of the handle. When using a comb, with the *left* she may hold the comb uneasily in her left hand, not knowing what to do, or carry the comb to the forehead, and make up and down movements. She uses the comb and whisk correctly with her *right* hand. She may sometimes use her *left* hand appropriately; on one occasion she tied her laces, on another occasion she buttoned her dress correctly, but re-testing with a variety of objects always gave the same result: she had no difficulty in handling objects with her *right* hand, but was only rarely successful with her *left*.

*Expressive and other willed movements of the hands:* When asked to salute, wave, threaten or knock, she makes abortive or amorphous movements with her *left* hand. These movements are often stereotyped in character, and perseveratory; the most frequent reaction is a movement of the forefinger towards the thumb. She cannot point out a figure or simple geometrical figures with her left fingers. When she is asked to bend or stretch the various joints of the left arm she is unable to do so. Her left arm may become rigid or she carries out mass movements. She is able to carry out the same orders correctly with the *right* hand.

*Purposeful movements of the legs:* She is unable to make a circle or mark out a number with her *left* foot. She cannot put her left heel or her toes on the floor, or swing her left leg to and fro. All these movements are carried out correctly with the *right* leg. She succeeds only occasionally when asked to lift the *left* leg, or *bend* it, but has no difficulty in these movements with the *right* leg. The movements with the left leg are as a rule amorphous and there is also strong perseveration.

She has difficulty in *dressings*, mainly because of inappropriate movements or confusion with her left arm. She may, with her left hand, tear at the cloth instead of slipping in, or does not know how to slip her left hand into the sleeve.

*Body orientation:* When asked to *point* at various named parts of the body with her left hand she either appears to be puzzled and confused or she may move the left hand about aimlessly, or use her right hand. She is only on rare occasions able to carry out the order correctly with her left hand. When she is ordered to carry out similar movements with her *right* hand, she does so correctly, when she had to point out parts of the right side of the body. She also points out correctly nose, mouth and forehead. But she is usually unable to point out with her *right* hand parts of the *left* half of the body. She will instead put her right finger to identical parts of the right side of the body or seems to be undecided where to point. On some occasions after she had pointed to corresponding parts of the right side instead of the left, when prompted to look for the other side, she says "It must be here"—pointing into space. The same reactions occur when she is asked to *point* to specific fingers; she can always point with her *right* hand to a finger named on the *right*, but is never certain as to the fingers of the *left*. She may for instance point at the left middle finger instead of the thumb, and then after a while, realizing it was wrong, point at the right direction, but not at the thumb itself. On one occasion when she had pointed before to the little finger and been asked to point to the middle finger, she again points to the little finger and says after a while "It seems funny that I should have two *first* fingers". She can name the parts of the body and the fingers on

the *right* correctly, but she is often uncertain and makes mistakes when asked to name parts of the body, particularly the fingers on the *left*.

Once she puts her *left* hand into action she is able to touch or grasp objects in front of her; but often the left hand does not come forward, she remains motionless or uses the right hand instead. In the first period of observation she used her *right* hand promptly when asked to do so; in later stages it sometimes occurred that her right hand remained inactive, and very occasionally she would move her left hand instead.

*Reaction to tactile stimuli:* When tactile or painful stimuli were applied to the *right side* she could as a rule locate the stimuli when acting with her *right* hand. She could not do so when she had to use her left hand. When such stimuli were applied to the *left side* of the body, in particular to the extremities, she was usually unable to locate them with either hand, and she would often point into space or sometimes to the right side of the body; there was as a rule, some reaction indicating that she had perceived the stimulus. In these reactions there was no difference whether she had her eyes open or closed.

*Writing, Drawing and Construction* (Fig. 1): In the first period of observation she could write with her *right* hand on dictation letters and words correctly, with only an occasional slip. Later on, when longer words were dictated, she would easily tire and stop in the middle of them, and could not be induced to finish the word. The writing also became slow and laborious, and more uneven, probably because of the increasing motor paresis of the right hand. With her *left* hand she was not able to write at all. She made only haphazard strokes when letters or words were dictated; the result was the same when she was copying. She spelt words promptly without mistakes. She drew *figures* correctly with the *right* hand, but was not able to write on dictation or copy figures with the *left* hand.

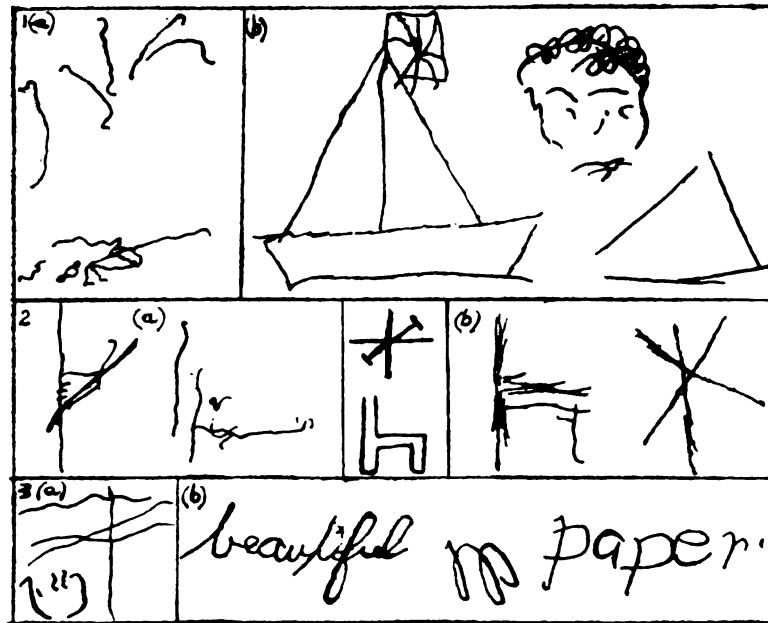


FIG. 1.—(1) *Free drawing:* (a) Left hand; no organized production is obtainable; (b) Right hand; boat, face, triangle. (2) *Copying of drawings:* (a) Left hand; (b) Right hand. (3) *Writing on dictation:* (a) Unorganized scribbling with the left hand; (b) Adequate writing with the right hand.

She could at the start *draw* simple objects such as a man, a boat, and geometrical figures such as a triangle and square in a fairly appropriate way with her *right* hand, and was able to copy more complicated patterns. Later on, the drawing with her right hand deteriorated to some extent. She made spatial mistakes, she had to be constantly prompted and often left the drawing incomplete. With the *left* hand she was incapable of drawing anything but haphazard lines, cross and square, without indication of any design. The copying with the *left* hand was much the same as the free drawing. She was entirely helpless with the *left* hand in copying of simple figures made of matches or in Kohs' blocks design, or wooden blocks, and did not know how to start; she interfered with the matches or blocks laid out, or shifted them aimlessly about. Only on one occasion was she able to do the formboard after many unsuccessful attempts.

She could carry out the same constructional tasks without difficulty with her *right* hand at the beginning of the observations, but in the later stages she became uncertain with this hand too and although she might start fairly adequately she could not complete the patterns, or get the blocks in the right order.

*Stereognosis:* She was unable to recognize objects by tactile means, with her *right* hand when the eyes were closed. With the *left* hand her reactions varied considerably; she would in a particular session identify some objects and not others, and would do better in some interviews than in others. She never had any difficulty in naming objects by visual exposure which she could not identify by tactile means.

The patient was sent to the Neurosurgical Unit at Killearn at the beginning of October, 1955 with the clinical diagnosis of cerebral tumour, probably originating from the C.c. An angiogram taken at this Unit showed a very large area of tumour vessels in the left parietal-parasagittal region, and some tumour vessels were also visible to the right of the mid-line. It was felt that this was a malignant glioma with a bilateral parasagittal distribution and no attempt was made to explore the lesion. The patient returned after 10 days to Crichton Royal. Subsequently the symptoms of the left limbs remained essentially the same; on the *right* hand writing and constructional disturbances appeared, though much less severe than on the left, and occasionally a hesitation in using her right hand when requested was noticed. Though the patient was quite alert and could still be tested, her retention and memory functions gradually deteriorated and she became more apprehensive and agitated when tested. At the beginning of 1956 she became more apathetic and less responsive, generally weaker, lost weight and was confined to bed; the motor paresis of the *right* arm and leg increased and there was also some loss of motor power on the left leg. She died on 22 March, 1956.

#### *Anatomical Findings*

On a sagittal section separating the hemispheres, a tumour can be seen which occupies four-fifths of the corpus callosum, leaving only the genu of the corpus callosum intact (Fig. 2). The tumour infiltrates both hemispheres, the left being more extensively damaged than the right. On both sides the posterior half of the cingulum is damaged. On the *left* there is a diffuse infiltration of the paracentral lobe and the praecuneus; on the *right* the infiltration is mainly confined to the cingulum.

Cross sections were carried out; *Section I* just in front of the temporal poles. It shows tumour tissue in the corpus callosum of both sides and infiltration of the lower portion of the cingulum, on the left more than on the right; on the left there is some expansion of the tumour into the central white matter.

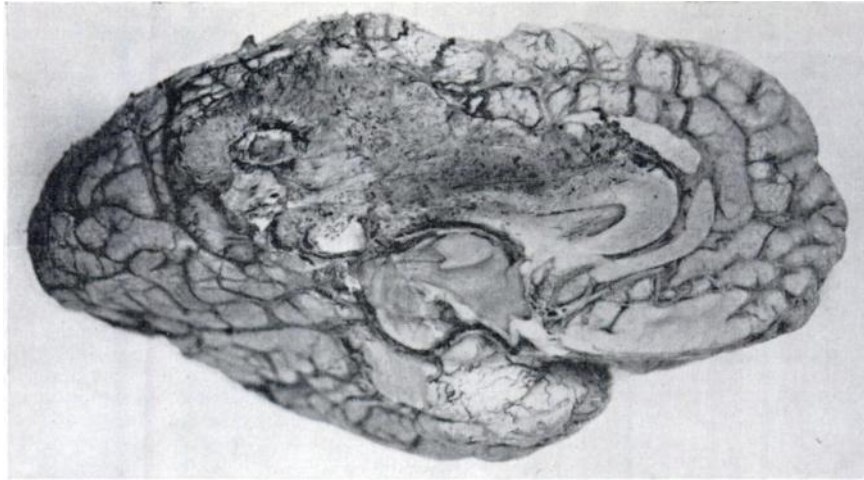
*Section II* is just in front of the mammillary bodies. The C.c. is completely destroyed by the tumour on either side. On the *left* there is a total destruction of the cingulum, and some infiltration of the medial sector of the white matter of the frontal lobe. On the *right* the infiltration is limited to the lower portion of the cingulum.

*Section III* was carried out at the level of the geniculate bodies. The C.c. on both sides is entirely replaced by the tumour. On the *left* the tumour occupies a slightly larger area than on the previous section, destroying the cingulum, the medial sector of the white matter of the anterior central gyrus, and the lower part of its upper sector. On the *right* there is an infiltration of the lower portion of the cingulum and a slight damage of the most medial part of the white matter underlying the anterior central gyrus.

*Section IV* is at the level of the pulvinar. The C.c. is on both sides destroyed, the cingulum is on the *left* replaced by the tumour, on the right only its lower portion is damaged. The damage to the white matter is on the *left* more extensive than on the previous section; it involves again the medial sector but occupies more of its upper and lower portion. There is a fairly fresh haemorrhage into the lateral sector. The infiltration on the *right* is about the same as in the previous section.

*Section V* is just behind the thalamus. The area of infiltration is here at its largest on both sides. The damage to the C.c. and cingulum is about the same

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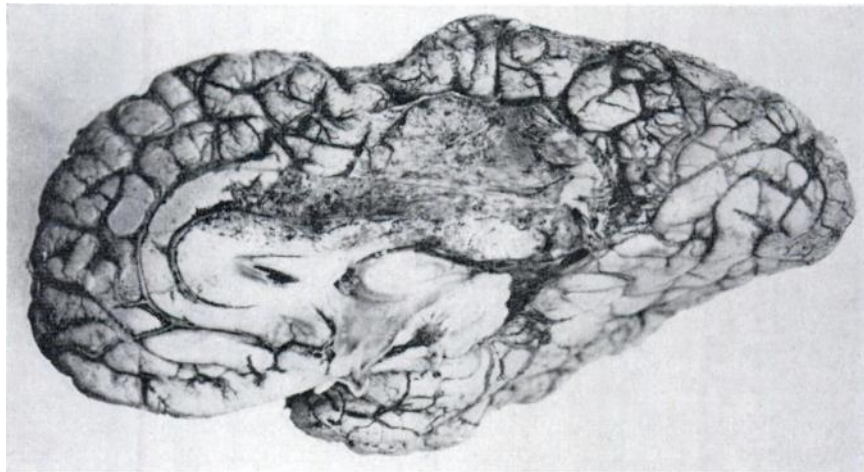


FIG. 2.—(L) Left hemisphere: (R) = Right hemisphere.

as in the previous section. On the *left* there is an infiltration of the medial and central sector of the white matter underneath the posterior central gyrus, superior parietal lobe and hippocampus. On the *right* the tumour occupies mainly medial and lower parts of the white matter in the areas of the superior and inferior parietal lobe and hippocampus; there is a fairly recent haemorrhage in the joining lateral sector (Fig. 3).

*Section V* carried out on the parieto-occipital border. The tumour has, on both sides, considerably decreased in size. On the *left* it is of plum size and sharply demarcated, occupying the lower part of the cingulum. On the *right*, there is some infiltration of the central sector, damaging mainly the white matter of the superior parietal and angular gyrus.

The *histopathological* examination of the tumour showed the picture of a glioblastoma.

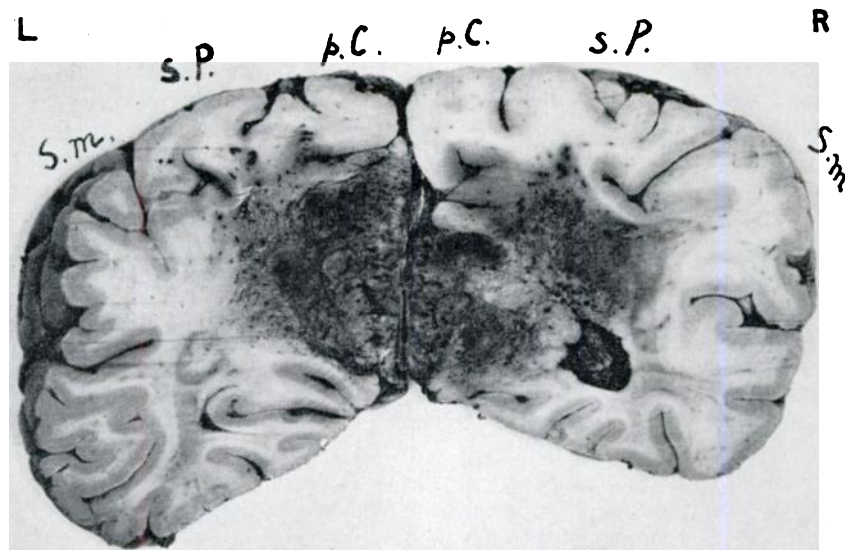


FIG. 3.—(L) = Left hemisphere: (R) = Right hemisphere: p.C. = Posterior central gyrus: s.P. = Superior parietal lobe: s.M. = Supramarginal gyrus.

#### SUMMARY OF CLINICAL AND ANATOMICAL FINDINGS

In a 61-year-old right-handed female patient with symptoms of increased intracranial pressure, the outstanding features were disorders at a higher level affecting the left extremities; there was a dyspraxia of both left limbs, a severe dysgraphia, severe constructional disorder, a finger agnosia and difficulty in identifying objects by tactile means, a non-realization of the left side, with autotopagnosia, and failure to locate sensory stimuli applied to the left extremities. There was no motor loss and probably also no sensory loss on this side. On the right there was a motor paresis, an ataxia and an astereognosis, and at a later stage, writing and constructional difficulties and on occasion some lack of awareness. Mentally she presented the picture of an amnesic syndrome.

A tumour was found which destroyed the C.c. with the exception of the genu, and infiltrated both hemispheres. The *left* hemisphere was infiltrated in its entire length; the largest damage was in the white matter of the anterior and posterior central gyrus. On the *right* there was a small lesion in the frontal region, and extensive damage of the white matter of the superior and inferior parietal lobe.

#### DISCUSSION

The most outstanding feature in the symptomatology of the case is the disturbance of the left extremities. Though it is not uncommon to find that a cerebral lesion affects a number of functions different in character, it is rare that such disturbances should affect only one side of the body, and in particular the left side in a right-handed person. However, among these disturbances in our case the dyspractic disorder and the imperception phenomenon are known to have particular relations to the left side of the body.

*Dyspraxia* has been observed as a rule in lesions of the left dominant hemisphere; it is then usually bilateral although less on the left than on the right limbs. Liepmann, who introduced this disorder, postulated (1900) that the

dominant hemisphere regulates purposeful movements for both sides of the body, the left side being directed through fibres of the C.c. connecting corresponding areas of the right hemisphere. In accordance with this conception dyspraxia restricted to the left side could be expected to occur by damage of the C.c. and such cases have since been reported. However, this role of the C.c. has been more recently challenged in investigations carried out after surgical section of the C.c. (Akeleitit, 1942; Smith, 1952). Akeleitit found that a left-sided dyspraxia appeared only when at the same time clinical signs of damage of the hemispheres were present. This may, functionally, also apply to a case of softening of the C.c. described by Sweet (1941) in which dyspraxia of the left side appeared after ventriculography.

Only a small number of solely left-sided dyspraxia cases with anatomical findings are recorded: in all of them the C.c. was damaged (Foix and Hillemand, 1925; Critchley, 1930; Braunmühl, 1956). In the cases in which a more careful examination was carried out, dyspraxia was not the only disturbance of the left limbs. Agraphia of the left hand was noted in all the cases in which testing of writing has been mentioned. Astereognosis without sensory loss has been noted in the case of Vleuten (1908) and in that of Goldstein (1908) and in Case 15 of Akeleitit (1942). Liepmann and Maas (1908) noticed at some sessions that their patient always touched the wrong body parts, and the patient of Vleuten could not point with the left hand to anything outside her body or to any part of her body. Goldstein's patient remarked that "The arm and I are two different persons", and Akeleitit (Case 15) notes that the patient becomes confused and apprehensive when the left side was tested. These descriptions are very similar to the description given by our own patient.

There is more case material available in the literature as regards the *imperception of the left side of the body*. In the cases described, unawareness is usually the only manifestation of a disturbance at a higher level. It has for this reason, attracted particular attention, and has been considered a phenomenon with its special physio- and psycho-pathology (Pözl, 1924; Klein, 1926, 1945; Conrad, 1930; Ehrenwald, 1931, Ives and Nielsen, 1932; Frantz, 1950; Hécaen and Ajuriaguerra, 1952; Critchley, 1956; and others). Imperception has been connected with the concept of the body scheme, i.e. the knowledge and awareness of the body and its parts and their relation at a given time. As the disturbance has mainly been observed in damage of the non-dominant right hemisphere, the suggestion has been made that the maintenance of the body scheme is a special function of the non-dominant hemisphere. The anatomical finding in the cases described shows great conformity; there is a lesion in the right parietal region which involves in some cases the cortex, in others the thalamus. This is also the area of the right hemisphere, which in our case has been mainly damaged. The clinical setting in these cases, is also fairly constant; together with the unawareness a severe motor and sensory loss on the left side is the rule. This occurs with such regularity that this loss, especially the sensory loss, has been regarded by some authors as the essential factor in the production of the imperception phenomenon. This particular setting has another aspect which is of no less importance, though it has not had the consideration it deserves. It is evident that the motor and sensory loss must necessarily greatly restrict the range of examination; thus it will not be possible to test the ability to carry out purposeful movements, writing or construction; in fact almost the only information about functions above a sensory-motor level which can under these circumstances be obtained as regards the left limbs, is that connected with awareness, the disturbance of which is the outstanding feature in these

cases. Considering the incompleteness of the data, it therefore seems hardly permissible to regard this disorder as the fundamental problem; one will have to keep in mind that the actual disturbance may be much more extensive than it appears phenomenologically.

To sum up, considering the clinical data in left-sided dyspraxia and the particular setting in left-sided imperception, there is not enough justification to regard either of these phenomena as a distinct and separate problem which requires its own interpretation. In our case, in which a different setting permitted a more complete investigation, both these phenomena were part of a complex symptomatology.

When we described the symptoms of the left limbs in our case we applied the terminology generally used and thus distinguished disorders such as dyspraxia, astereognosis, agraphia, and so forth. Such distinction is made with reference to corresponding faculties which are regarded as special functions or relative entities of normal mental activity. It is the conventional approach to view disorders at a cognitive level in the light of such psychological or psychophysiological concepts. This reference to selective mental processes as regards disturbances due to cerebral damage and the corresponding terms, has been generally adopted, whatever the particular school of thought. Though this approach has proved to be in many ways profitable, there is no reason to believe that cerebral disorganization should necessarily follow this particular pattern.

In our case there can be no loss of faculties as such, since the patient is able to carry out the same tasks with her right limbs which she is unable to perform on the left side. The distinction of disorders, referring to special faculties, can therefore only be of descriptive value.

But this apart, the problem in our case is not the presence of one or another specific disorder, but the fact that the left limbs are disorganized *in all the modes of their activity* and that this affects the left limbs only; they are functioning at a purely sensory-motor level, and have more or less lost—this applies particularly to the hand owing to its high organization—all the qualities which constitute their specific character (R. Klein, 1930, 1947).

As to the *psychological* background and mechanism of the massive disorganization of the left limbs, the patient's reactions and her own description seem to point to a more general factor responsible for the disturbance. There is the panic reaction, the patient's complaint of going to faint, and the occasions of complete inertia when the left hand is being tested. The patient referring to her left hand, speaks of a "nerveless hand" which does not obey her, or of a "mixed up feeling". It appears that her difficulties arise whenever she has to *transact* and *mediate* cortical activity through her left limbs, regardless of the particular character of the task, or whether the task is simple or complex. When the patient operates her left limbs she does so without concept of space or sequence, she cannot make discriminations and classifications; there is no organization at a conceptual level and the general principles of an orderly thought process are missing. One can say that the patient operates the left limbs *without intelligence*. As she is able to carry out adequately corresponding tasks with her right limbs, we cannot assume that the intelligence necessary for these tasks is missing. One can regard intelligence as a *potential* which is normally *delegated* to such functional fields as the situation requires. It seems that this *delegation does not materialize* in our case when the left limbs are the agents of cortical activity; they are dissociated from this activity.

As to the *pathophysiological* mechanism of this dissociation of the left



limbs, the *anatomical* findings of the case, the extensive character of the damage does not, at first sight, encourage an interpretation of the picture; there is a complete destruction of the C.c. with the exception of the most anterior part, and a deep infiltration of both hemispheres. However, the area of damage which can possibly be related to the left-sided symptomatology can be narrowed down. We can disregard the lesion of the left hemisphere as it can hardly be responsible for the homolateral disorder. We can also neglect the lesion of the right frontal region, where the damage was only very minor. There is therefore only the damage of the right parietal region and that of the C.c. to be considered.

Since the non-dominant right hemisphere is known to be of importance for a variety of functions at a higher level, it would not be surprising if it had also some role to play in such functions of the left limbs. This has some support from anatomical and physiological facts; the limbs and hemispheres represent a unilateral neuroanatomical unit and each pair of limbs has its own independent field of action. Significantly, the dyspraxia in our case leaves unaffected not only the right limbs, but also the bilaterally innervated facial muscles. Nor is it unexpected that the main damage of the right hemisphere should be situated in the parietal region; as this is the site of the damage in the cases of left-sided imperception, a phenomenon which is also part of the symptomatology we described. There is, however, this difference. In the imperception cases the area of the motor and sensory pathways is usually involved, whereas in our case this area is intact. We have previously discussed how this difference in the clinical setting may affect the phenomenology. Therefore it may well be that the massive disorganization which we found in our case expresses more accurately the pathophysiological significance of this area than the isolated imperception phenomenon in other observations. If this is the case, one could regard, in accordance with our previous conclusions, the right parietal region as an essential area of a circuit which has the task of maintaining the activities of the left limbs at a conceptual level.

More difficult to assess is the significance of the destruction of the C.c. in our case. The idea of a regulatory influence of the dominant hemisphere upon the motor actions of the non-dominant hemisphere by the fibre system of the C.c., attractive as it is, is not supported by more recent observations (Akeleitits, 1942; Smith, 1952). Bremer (1956) considering mainly animal experiments, suggests that the C.c. may be concerned with the "transference of amnesic acquisitions" from one hemisphere to the other. There is, however, no symptom or defect which would occur with some regularity after damage or sectioning of the C.c. in humans and in EEG records the bilateral synchronization of the fundamental cortical rhythm is still present after the C.c. had been sectioned (Hursch, 1954). One could imagine that the C.c. has a co-ordinating function between the two hemispheres during the period when cortical functions are in the stage of development. Once this phase has come to a conclusion and synchronization and co-ordination are well established, its importance may lessen; but when, subsequently, damage of significant areas of the more dependent, non-dominant hemisphere occurs, the fibres of the C.c. may serve to re-establish the co-ordination through other circuits. If, however, the C.c. is at the same time destroyed, as it is in our case, and in some cases of Akeleitits, this compensatory mechanism cannot operate. It may be that the disturbance of the left limbs in our case represents thus a maximum effect produced by the combined lesions of the right parietal region and the C.c.

The disorder of the left limbs was the most outstanding feature of our

case; there was at the beginning no such disorder in the right limbs, although the patient had on this side a slight motor paresis and some sensory loss. But in the later stage she had difficulty in writing and construction also with her right hand, though less marked than with her left. It is possible that this may have been due to the local damage of the left parietal region, and was the beginning of a disorganization similar in character to that of the left limbs. But it is also possible that the progression in general intellectual loss played a part, as construction and writing are specially prone to be affected at a fairly early stage in dementing processes.

Finally, some remarks about the patient's attitude to her illness and defects. As regards her illness in general, she is rather casual, does not seem to be concerned, and does not feel there is much wrong with her. She will admit that her gait is somewhat unsteady and attributes this to her anxiety. Anxiety is frequently given as an explanation for her failures when being tested. On other occasions she may be well aware of her difficulties and describes for example very lucidly the character of her disturbance of her left hand. Then again she may neglect a particular defect as she does fairly consistently the weakness and ataxia of the right arm. In general, the awareness of the symptoms varies in degree, it is not constant for a particular symptom, and is fluctuating with the change of situation. There is obviously some fault in registration; she registers her defects only when stimulated, and when she does so the registration is only fleeting; it is consequently not consolidated and firmly established. The failure to realize alterations in bodily functions has usually been connected in the literature with the body scheme, and it has been more or less implied that there is a disturbance of this scheme in a *functional capacity*. This is clearly incorrect for our case, as it is probably for most other cases of this kind which have been reported. Our patient shows a marked amnesic syndrome; a disturbance in registering data, particularly those of recent origin, is characteristic for this syndrome. It results in a lowered awareness which is general and will necessarily affect new experiences of body functions, as it affects such experiences from other sources. This type of disturbance involves in our case also the left limbs; but there is at the same time an unawareness, which has nothing to do with retentive processes; it is an unawareness of the left limbs as such, of their place in space and even of their existence which is restricted to the left side. This is in our case part of the left-sided syndrome, discussed previously.

#### CONCLUSIONS AND SUMMARY

A disorganization in the responses of the left limbs is described in a 61-year-old right-handed female patient, who had a tumour of the C.c. which infiltrated both hemispheres. The patient was unable to use the left limbs in an appropriate and purposeful way, to differentiate their parts and locate them, to identify objects by tactile means, to write or construct with her left hand, and she was also unaware of her left limbs.

The conventional terms such as dyspraxia, agraphia, imperception and so forth, which denote these disorders, are in this case only of descriptive value; there was no loss of corresponding faculties as implied by these terms since the patient responded in most respects adequately with the right limbs. Nor, for the same reason, is the disorganization due to a lowering of general cortical functions. The nature of the disorganization is regarded as operational; the patient is unable to apply her intelligence when the left limbs are employed

as the agents of cortical activity. We may consider intelligence as a potential which can normally be directed to any field of operation. In the case described, this shift failed to take place when the patient operated the left limbs.

In the light of the massive disorganization of the left limbs, the problem of left-sided dyspraxia and left-sided unawareness has been reviewed. There is evidence that the left-sided dyspraxia is, in the cases described, not the only disturbance at the conceptual level of the left limbs. As to unawareness of the left limbs, this is as a rule associated with motor and sensory loss on this side which greatly restricts investigation; disorders such as found in our case may therefore remain undisclosed. To approach these phenomena without considering this particular setting is likely to lead to false conclusions.

There was in our case, distinct from the imperception of the left limbs, which formed part of the left-sided syndrome, a lowered and fluctuating awareness of illness and of particular defects. This is part of an amnesic syndrome present at the same time.

Anatomically the damage which can be related to the left-sided syndrome was in our case the lesion of the right parietal region, and that of the C.c.; these are the areas which are involved in cases of left-sided imperception and left-sided dyspraxia respectively. It is suggested that the right parietal region may be a focal point in a circuit which maintains activities of the left limbs at a conceptual level, and that the C.c. may have a subsidiary role in that function.

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