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Disorders of Attention: A Frontier in Neuropsychology

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Disorders of attention: a frontier in neuropsychology

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There is an extensive behavioural neurological literature on so-called unilateral attentional disorders, but a striking paucity of papers on global disorders of attention, i.e. confusional states. However, confusional states are distinctive because: (1) they are the most common disturbance of the higher functions in clinical practice, by orders of magnitude; (2) they are the only disturbance of the higher functions from which all normal subjects have suffered; (3) they have characteristic clinical manifestations; (4) they are frequently misdiagnosed as progressive dementias, aphasia, memory disorders, and psychoses; (5) they are the only disturbance of the higher functions that commonly cause patients to produce statements that appear to be extremely witty; (6) they can be readily studied experimentally; (7) they are the most common cause of unconcern with or denial of illness.

There are almost certainly several different forms of confusional state depending on the aetiology, the rate of development, the age, and the anatomical systems involved, but little classification has yet been carried on. Confusional states are most simply defined as disorders in which there is a loss of the normal coherence of thought or action. Among the striking clinical features are: (1) failure to pay attention, excessive distractibility, or failure to shift attention; (2) paramnesias, i.e. distortions of memory; (3) reduplicative phenomena, 'wild' paraphasias with 'propagation' of error, alterations of mood in many different directions; (4) isolated or predominant disturbance of writing (the most common cause of pure agraphia); (5) unconcern with or denial of illness; (6) apparently playful behaviour.

While confusional states are usually attributed to 'global involvement of the brain' as a result of metabolic or toxic disorder, there are in fact many cases produced by focal infarctions in the right hemisphere, which, in the experience of my department, is one of the commonest effects of cerebrovascular disease. Brief reference is made to the prognosis, and to the theoretical significance for cerebral dominance and the evolutionary development of cerebral dominance in non-human species.

1. Introduction

It may well be surprising to investigators who have worked in the new field of brain–behaviour relations, and to those who are familiar with the literature in the field, to be told that disorders of attention represent a frontier in neuropsychology. They would probably accept this phraseology if it were simply meant to convey that, as in all other areas of study of the relation of the brain to behaviour, our ignorance is vast and we are only at the very beginning of scientific investigation. On the other hand, they would probably express disagreement if they were told that the implication of this title was that little research had so far been done on this problem. Indeed even the casual reader of the literature on derangements of the cerebral cortex and

related systems could rapidly find an enormous number of papers dealing with the problem of *unilateral* inattention.

It is therefore appropriate that I stress at the very outset that I am not planning to write about this very classical problem of so-called 'unilateral disorders of attention' in which there are a rich literature and many superb papers. By contrast, what will be emphasized in this presentation are disorders of attention that are not confined to one side of space. An obvious question that may arise is that of the relation between the unilateral or hemispatial disturbances of attention and those more global disorders that will be discussed here. Limitations of space prevent me from going into this important problem but one or two remarks may perhaps be appropriate at this point. In the first place I would suggest that the disturbances that have been included under the rubric of unilateral attentional disorders include a variety of conditions of various mechanisms. In some instances I would argue that whatever the practical and theoretical interest of many of these conditions is, some of them are in fact, strictly speaking, not disturbances of attention in the sense that I shall be using in this paper. There are, however, certain circumstances when unilateral disturbances of orientation to one side of space are in some instances true disturbances of attention and the full understanding of their mechanism can be attained only by consideration of the more global disorders. I would in fact suggest, although I shall not elaborate on it here, that the great predominance of inattention to the left side of space and of the body can be accounted for only by a theory that takes into account the dominance relations of the more global attentional systems to be discussed here.

There is of course also an extensive literature on the disorders of attention that may arise in both the human and animals as the result of subcortical lesions, and in particular those that lie within the reticular formation of the brain stem. As is well known, the discovery of the effects on arousal of lesions within the upper brain stem, reflected in the work of such authors as Magoun, was one of the major neurophysiological discoveries of the past few decades. In addition to the classical animal investigations, there were many papers giving detailed accounts of patients in whom lesions in the same location produced remarkable clinical states including the classical akinetic mutism or, as the French call it, *coma vigil*. These patients could show a dramatic clinical state in which they appeared to be awake, but were typically totally unresponsive to the stimuli that would readily arouse normal subjects. I believe it is correct to say that these lesions were almost certainly in a system that played an important role in the arousal of behaviour, and as such they are representative of disorders of a basic system that is necessary for the proper operation of the attentional systems of the cortex.

The frontier in neuropsychology to which the title refers is therefore a different group of conditions from those that have been dealt with in considerable detail in the past in the literature on both humans and animals. This paper will deal with a group of disorders that follow lesions in the cerebral cortex in specific locations and very possibly in other portions of the hemispheres. They have a rich clinical symptomatology, they are common, and in my view they represent disturbances of one of the highest levels of complex functioning of the nervous system.

2. General overview

In the following sections of this paper I shall define the sense in which I am speaking of attentional systems. I would point out their great complexity, which is evident not only from observation in everyday life but also from the experiments of such workers as Broadbent. The

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great complexity of the systems and their dependence on previous learning are alone sufficient to make it highly unlikely that their neural representation could be entirely within brain-stem structures of limited extent.

The disorders of attention have many striking characteristics that make them well deserving of closer attention on the part of neuropsychologists. In the first place, deficits of attention in normal subjects are one of the most common causes of failure to observe correctly the events in the environment or to learn. Every reader of this paper will surely have had the experience of attending a lecture of an hour's duration, during which he was fully awake and yet could give no account of what had gone on during that period despite the fact that there were no limitations of a sensory nature to prevent correct perception of the content and although the talk was delivered with perfect clarity in the native language of the listener. It is of course a common experience to hear people say that they had no idea of what had been going on since they had not been paying attention. Furthermore every teacher from elementary school to the highest levels of university life is familiar with the fact that one of the major reasons for failure on the part of students is lack of attention to the material being presented.

Yet, curiously, it is rare for a neurologist or a psychologist to attribute a patient's failure in tasks of comprehension, performance, and memory to a failure of attention. In good part this is the result of the fact that in ordinary life such dramatic failures of attention occur overwhelmingly in circumstances in which the listener is within a large group. By contrast such failures of attention are a good deal less common in face-to-face interaction between two people. Furthermore, when they do occur in ordinary life in the dialogue situation one is very apt to attribute them to distraction by other important thoughts, depression, or even a deliberate lack of cooperation. These modes of interpretation of failures of attention are so common that even in the situation of clinical or psychological examination there is a tendency to neglect the possibility of neurological disorders directly involving the higher level of the attentional system and therefore to attribute the patient's failures either to other types of cognitive defect or to purely psychological factors such as depression or uncooperativeness. The unilateral disorders of attention have, on the other hand, not escaped neglect so readily since the dramatic contrast between the patient's performance in the two halves of space is so striking as to command notice rapidly. Furthermore the global disorders of attention, on which the stress will be laid here, so typically lead to a failure of performance of the patient in standard examinations that the patient is likely to be regarded as untestable.

(*a*) *Disorders of attention resulting from brain disease*

The disturbances in attention as a result of a disorder of the nervous system go under many different names, e.g. delirium, confusion, or even 'the acute brain syndrome', a barbaric nomenclature that has become widely used especially among American psychiatrists. There are, of course, 'standard' descriptions of these conditions, especially in psychiatric textbooks, but as I hope will become clear many of these descriptions are likely, on the one hand, to omit the cardinal defects in the patients, and on the other hand, incorrectly to describe as characteristic certain features that are irrelevant to the diagnosis and indeed are often absent. Thus the term 'disorientation' is often used and the general impression on the part of many clinicians is that this describes the same type of failure of acquisition of new knowledge that one may see in the familiar amnestic syndrome. Two features that are mentioned, but which are indeed unnecessary and frequently absent, are agitation and hallucinations.

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(i) *Some distinctive features of confusional states*

In this paper, I shall generally use the term 'confusional states' to describe these conditions. They are distinctive and important for the following reasons.

1. They are by many orders of magnitude the most common disturbances of the higher functions in patients suffering from brain lesions.

2. They are the only disturbances of the higher functions from which all normal subjects have suffered.

3. They have characteristic clinical manifestations, many of which are seen with great regularity and these manifestations are often strikingly intriguing.

4. They are very frequently misdiagnosed as progressive dementias or as aphasia, memory disorders, or psychoses.

5. They are most unusual in being, to my knowledge, the only disturbance of the higher functions that commonly cause patients to produce statements that appear to be extremely witty. This too can lead to a misinterpretation of the patient's behaviour as deliberate teasing.

6. They can be studied experimentally in a way that many of the other higher functions cannot. Thus it is extremely difficult, except under most unusual circumstances, to produce a transient aphasia in a patient that can be investigated and then recover. By contrast there are some simple situations in which, without any violation of ethics or reasonable rules of safety, these conditions can be produced and investigated.

7. They are by far the most common cause of unconcern with or denial of illness.

3. Definitions

(*a*) *Attentional systems*

The problem of attention has of course been a central one in psychology for many years, and M. I. Posner, who is participating in this Discussion Meeting, has of course devoted considerable investigation to this problem as have D. E. Broadbent, F.R.S., and many other distinguished psychologists. I shall not attempt here to give a detailed discussion of the definitions, but rather I shall stress certain aspects of the attentional systems and their importance in biology. The features that I shall discuss include selectivity, coherence, distractibility, universality, and sensitivity to specific circumstances, the meanings of which should shortly become clear. These categories are not mutually exclusive but it is useful in consideration of the biological functions of attention to consider each in turn.

(i) *Selectivity*

Possibly the major reason for the existence of attentional systems of such complexity in higher animals is that in the normal state of affairs, they are subject in every instance to a huge number of stimuli, of which a very large percentage could demand some sort of innate or learned response. As William James pointed out, the world of the young infant was probably one of 'blooming, buzzing confusion'. In the presence of such large number of stimuli, it is necessary, if effective learning or action is to take place, that only a very limited number of these be handled at a given instant.

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(ii) *Coherence*

The biological requirement for selectivity grows, as was just mentioned, out of the situation that no effective performance is possible unless only a limited number of stimuli are dealt with at a given instant. It is, however, an immediate corollary to this property that not only must one or a small number of stimuli be attended to, but also that the selection be maintained over time in order to achieve coherent thought or action, without which effective thinking and effective performance are not possible. The animal that stalks his prey in the jungle under circumstances of scarceness of food is not likely to survive unless he can maintain this coherence for long periods.

(iii) *Distractibility*

The description so far of an attentional system carries with it, however, certain implicit dangers to the organism. Selectivity and coherence are necessary for effective action or thinking. Yet it is also true that the animal or human who has narrowed the scope of his focus to one or two items over a prolonged period of time is subject to many dangers. Thus the animal stalking his prey can easily be unaware of the fact that he himself is being stalked by another hostile creature. Furthermore it is obvious that while the maintenance of coherence is necessary to successful completion of an action, there are times when breaking off an action in order to take a different behavioural route is often desirable. The tiger stalking a small animal which, if caught, would barely supply his nutritional needs, might be well advised to shift if a larger prey, who could provide a much more satisfactory meal, should appear.

It is precisely this problem of distractibility that confers the greatest complexity on the system. In order for the animal to shift his focus elsewhere he must in fact be receiving information from the remainder of the environment. If he is indeed monitoring in some fashion the remainder of the environment, he will be made aware at some level of his nervous system of possibly hundreds of different stimuli, many of which could be of potential interest. If he is too readily distracted he will fail to carry through any single programme and will thus have lost coherence, which will lead to gross failures of behaviour. If he is distracted with only the greatest of difficulty, he will fail to respond to stimuli that are either dangerous or potentially more useful.

It is therefore reasonable that this process of monitoring and shifting should have certain characteristics. The organism must be capable at some level of screening the environment. He must have a set of rules that determine the criteria that lead him either to shift his focus or to maintain it on the item already selected. In his classic experiments, Broadbent has looked at some of the characteristics of this type of system. The range of items monitored must be very wide indeed, so that they will include not only stimuli reaching the body from without but must also include internal stimuli. It is fairly obvious that at most instants we are unaware of the state of our bladder or bowel at a conscious level. Yet it is extremely rare for a normal adult, indeed unheard of, to urinate or defecate spontaneously in the course of a conversation.

The rules for distraction are complex and clearly depend on the state of the animal and on his previous learning. An animal who has never acquired the information that a particular fruit is edible is less likely to be distracted by its presence when he is hungry than an animal that has already acquired this information. On the other hand, the sheer novelty of a stimulus is likely to be of importance in distraction. The biological utility of this is clear. The animal

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that is driven by novelty will indeed possess a far better knowledge of his environment in the future and will be more likely to make correct decisions.

The monitoring system itself, although typically outside of consciousness, must also make some complex decisions as to where to centre its own focus. Thus it may be unable to monitor all events in the environment successfully because of limitations on channel capacity, and therefore some important decisions must be made. Even in ordinary language this property of these systems is noted. A child who stumbles over a rock in the street, when walking in the dark, is likely to be berated by his parents for not paying attention. Even in going down a dark street it is obviously important that this concealed or monitoring system devote itself more intensively to those regions from which it is difficult to get information. The precise features of the system's control of distractibility are ones that determine some important characteristic features of personality. The classic absent-minded professor may well be perfectly capable of concentrating his focus energetically on a specific topic for many hours of time. One aspect of attention is thus very well handled, i.e. selectivity, and of course also coherence. By contrast, a picture of such a person continuously concentrating on his books while firemen crowd through his windows and put axes in his roof without distracting him is well known. The very opposite is of course the highly distractible person, with the grasshopper mind of the advertisements in children's magazines 30 years ago or more, who is constantly shifting the central focus.

(iv) *Universality*

This topic has already been commented on in the preceding section. The prime feature of universality is that the monitoring system must in some way attempt to register as many unattended stimuli as possible, both externally and internally.

(v) *Sensitivity*

I have already made some allusion to this in discussing the issue of distractibility. Clearly the rules that determine shift of the central focus must, to be most efficient, depend sensitively on the state of the creature. There is nothing so effective as severe thirst to make someone be readily distracted by the sight of water, even in the furthest periphery of the visual field. Other classic instances of the same property are the readiness with which the sleeping mother wakes up to the cry of the baby but neglects the loud roll of the trains going by. Indeed this example raises the rather interesting point that the monitoring systems may be functioning at a high level even when selective attention is lacking.

4. Characteristics of confusional states

It becomes easy to define the confusional state when one looks at the properties of attentional systems that I have selected above for discussion. Confusional states are ones in which the normal coherence of thought or action is lost. When selectivity and coherence are typically low, the patient is too readily distracted. There may appear to be not even a simple reduction of the threshold for distraction since the patient may paradoxically be distracted by stimuli that are at best trivial, and fail to be attracted by stimuli of importance. He may shift attention when it is inappropriate and yet leave his attention rooted on some topic long after a shift has become appropriate. Thus we are no longer dealing with simply a lowering or raising of the arousal level, but rather a more profound disruption of the normal hierarchy of rules. Action

and thought lose their normal coherence, the patient responds in an inappropriate manner, and the line of his thinking becomes jumbled in a dramatic fashion.

The pathological confusional state is, as I have noted above, one condition from which all normal subjects have suffered at one time or another in varying degrees. Clearly the actor imitating the intoxicated person relies heavily on coherence in order to mimic the state of drunkenness, and the bizarre disjointed conversation of the inebriate is a common feature of comedy. Yet even without the deliberate ingestion of external intoxicants, confusional states occur in ordinary life. Everyone has probably suffered from these, particularly in childhood in the course of an illness with high fever. Yet there are even more common situations that persist right into adult life. Nearly everyone has had the experience of attempting while falling asleep to think about some particular topic or carry out a calculation only to find that the matter under consideration keeps slipping away being replaced by other intruding thoughts. Many people tell amusing stories of being awakened at night by a ring and after going to the door realizing that it was actually the telephone. Conversations carried on by those who have just awakened from sleep are of course often characterized by precisely these features.

(*a*) *Clinical forms of the confusional state*

In this discussion I shall not make an attempt to differentiate different clinical forms of the confusional state. It is obvious to me that these almost certainly exist, but aside from some vague impressions it is difficult to make a reasonable classification based on either functional or anatomical characteristics. Thus one of the most common forms of confusional state in the United States in cities in which alcoholism is frequent is delirium tremens. This certainly has many of the features that I will describe shortly but it also possesses certain distinctive features. Even if one leaves aside the elementary physical disorders such as ataxia and tremor, there are some characteristic psychological features. Thus agitation and fearfulness are extremely common in this condition but often lacking in other causes of confusional states. Hallucinations, particularly of small animals on the wall or running up and down the limbs, are extremely common, yet they are uncommon in many of the other conditions.

Furthermore, if one considers the confusional states from other causes one again finds a whole array of disorders that share in a common destruction of the hierarchy of rules for shifting attention, but some conditions have striking differences. Thus while certain forms of geographical confusion are common in all of these states, dramatic confusions of individuals, which I shall mention later, are much rarer. I have the vague impression that patients with confusional states developing from infarctions of the undersurface of the occipital lobe are more likely to give accounts of extensive and improbable travels than are patients with other focal lesions producing confusion.

Obviously this differentiation of the confusional states based on functional features and anatomical substrates will be a necessary prerequisite not only for an appropriate diagnosis but also for the creation of theories that will make possible experimental studies that will eventually make the simple model presented here appear even more naïve than it does now.

5. Clinical characteristics of confusional states

In this section I shall discuss some of the major clinical features of the confusional states and shall also present some of the reasons why they may be misdiagnosed in clinical practice.

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(*a*) *Loss of coherence*

This is of course the cardinal feature of the confusional state. The patient may carry on a conversation that is bizarre in the extreme because the topic of discussion may shift abruptly or the patient may persist in a topic that had been thought to be abandoned. The actions of the patient may show equal incoherence. Thus the patient in a confusional state may make many of the classic errors with which we are all familiar. He may move around the house at night in a random fashion. He may turn on the gas without lighting it, and he may put a pot on the stove to boil even though no water has been placed in it. This disruption of the overall pattern of action despite the correct performance of fragments is of course very reminiscent of the syndrome of ideational apraxia as defined by Hugo Liepmann at the beginning of this century. It is important to stress here that Liepmann's definition of this disorder is essentially one in which the programme of action is lost although the individual movements are made correctly. (The term 'ideational apraxia' has, however, been used by many authors in a quite different sense, i.e. difficulties in handling objects, and this description is often incorrectly ascribed to Liepmann.) One should note, however, that while Liepmann himself tended to attribute ideational apraxia to the kinds of states that we are describing here, it is likely that there is a smaller group of patients who show equally disrupted action sequences while lacking other confusional elements. Whether we are dealing here with variants of the syndromes of confusion or whether we are in fact dealing with disorders of action with a very different mechanism is something that remains to be determined.

(*b*) *Paramnesia*

Although it is common to read in clinical textbooks that patients in confusional states are disoriented and have poor memories, it is frequently clear that the patient is instead suffering from what Pick (1903) called 'paramnesia', i.e. *a distortion* rather than a *loss* of memory. Let me make this clear by pointing out that a paramnesia is an error in which the answers are incorrect although the elements of the correct answer are present, i.e. information is available to the patient and indeed has obviously often been learned. Thus one of the most characteristic forms is 'reduplicative paramnesia', in which the patient duplicates certain things, particularly geographical locations. The most characteristic confusions involve the home, the hospital and the place of work.

Thus Weinstein & Kahn (1955) described a patient in the Mt Sinai Hospital in New York who said, when asked where he was, that he was in a rest home in Florida. Yet when asked for the name of the rest home, he said, 'this is the Mt Cyanide Rest Home', a pun on the name of the hospital that could not be produced unless the patient had this information. Obviously one must exclude that these are errors produced by patients who might have been in that hospital many times. One sees, however, precisely the same manifestations in patients coming from other cities who have never been in the particular hospital in question. Thus a patient in the Beth Israel Hospital in Boston said that he was in Concord, New Hampshire, and when asked the name of the hospital immediately said that it was the Beth Israel. When questioned further about this by the examiner, he then said that there was indeed another Beth Israel Hospital which was located on Brookline Avenue in Boston but that he was in the branch in Concord, which of course does not exist. The patient may insist that he is in the Beth Israel Hospital in Boston but that this is really not the main Beth Israel Hospital, which is in another

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location but is a branch further down the street. Most typically, patients tend to move the hospital close to their own homes. On the other hand, one sometimes sees the reverse. One patient at the Boston Veterans Administration Hospital, when asked where he was, said he was in his own apartment. Asked for the location of this apartment, he said that he was on the 19th floor (which does not exist) of the V.A. Hospital. When it was pointed out to him that his address in the chart was different, he then stated that he had two apartments, one of which was in the Boston V.A. Hospital, and then proceeded to give correctly the address of the other apartment.

A dramatic, indeed bizarre and often eerie, version of reduplication is the much less common phenomenon of reduplication of persons, sometimes called the Capgras syndrome (Alexander *et al.* 1979). Thus the patient may say in response to a question that the woman he has just been speaking to is not his wife, although curiously enough she has the same name, the same appearance, and the same clothes as his own wife. Another patient insisted that all of the people he saw on the ward including the nurses and doctors were employees in the Government Center in Boston but were using assumed names to avoid taxes. Another feature of this reduplication is the patient speaking as if he were in his normal place of business, the classical 'occupational delirium' of the older literature. Thus a patient asked to name a particular person he had met in the hospital gave his name correctly with the prefix Dr, but when asked what he did said that he repaired shoes, the patient himself being a shoemaker. This illustrates the striking feature of many of these patients that with enough patience the examiner can often show that they are fully oriented as to time, place and person, and yet they will jumble the correct facts with many incorrect ones. Furthermore they will often justify these errors. Thus one patient insisted that she was in her own living room. When asked why her ring was wrapped in adhesive tape, the patient, who came from California, said that was to keep from losing it in the swimming pool. This process of justification is often striking. Thus this patient having identified the hospital room as her own living room, described the intravenous pole as a Christmas tree, and identified all other items in the room as being part of the furniture in her own living room.

(*c*) *Propagation of error*

The previous section has already alluded to this characteristic, i.e. that very often once the patient makes an error other items in the environment are brought into apparent coherence with this error. This may result not only in distortions of memory but also often in what appear to be dramatic errors of naming like those of the patient who called the i.v. pole for the intravenous fluids a Christmas tree decoration.

(*d*) *Occupational jargon*

Reference to this has already been made, but some special features of it deserve comment. Not only may the patient identify the hospital as his own place of work and the occupations of people in it as being identified with his place of work, he may also use occupational jargon in talking about things. This is especially true of patients who have been in military service or in bureaucratic positions who use curiously stilted language reminiscent of official documents, even in circumstances in which no one would use this type of speech. Thus a patient once said that 'this is an institution regulated for the purpose of improving the quality of the rehabilitation of automobiles' and another described his glasses as a 'non-mechanical optical instrument'.

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(e) Inattention to environmental stimuli

One of the striking differences between these patients and those with the classic chronic amnestic syndrome is the failure of the patient to use environmental information. It is true that many patients with alcoholic amnestic syndromes may in the acute stage show features of the confusional state, but in the chronic state these patients typically use environmental information very effectively. Thus the chronic amnestic patient lying in a hospital room and seeing doctors and nurses around him almost immediately will reply that he is in a hospital, while a patient in the confusional state may indeed deny this even when the evidence is around him on every side.

(f) Isolated or predominant disturbance of writing

One of the most curious features of the confusional state is the dissolution of writing in even very mild cases. Chédru & Geschwind (1972) studied this some years ago in an experimental manner. We had the opportunity to examine patients having anaesthesia induced with intravenous barbituates who were perfectly normal before the induction. During the short period of barbituate intoxication, the writing of the patient became grossly incoherent with a wide variety of errors. In some cases the writing was simply spatially abnormal, being scrawled in many different directions on the page. In other instances, however, the patient produced incorrect words and many misspellings. One particular characteristic of these patients is seen in the writing of words with letters that contain multiple loops that are often repeated incessantly. A patient with this very dramatic agraphia will typically have speech that is essentially normal from the point of view of grammar and word choice, even though one may occasionally hear paraphasic errors of the kind that I have mentioned earlier. Indeed the confusional states are probably the most common cause of pure agraphia. The neglect of this fact has sometimes led to misinterpretation in the neuropsychological literature.

(g) Unconcern or denial of illness

The confusional state is by far the most common cause of unconcern with or denial of illness. It is important to stress that the patient may be fully aware of the nature of his illness and yet show unconcern or denial.

(h) Playful behaviour

A dramatic feature of the confusional state is the production by the patient of funny and apparently often very witty remarks. This may have multiple causes. Many of these patients show the same type of crude unconcern (often mistakenly called 'euphoria', although 'facetiousness' would be more appropriate) that can be seen in the classical frontal lobe syndrome. On the other hand, careful examination will often reveal that in fact it is not true playfulness or facetiousness that lead to the funny remarks. In some instances this behaviour is so dramatic that some examiners think the patient is being cheeky or is deliberately teasing the examiner. It is particularly intriguing to see this type of behaviour in people who have never been particularly humorous and even at the height of the illness do not appear to be particularly playful. This mechanism of humour is one that again the expert comedian often imitates very well in his mimicry of the inebriated person. The apparent wit is not the result of deliberate humour on the part of the patient but is the chance result of the incoherent stream of speech that results in the throwing together of unusual ideas and phrases that are often extremely amusing.

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This is of course a most interesting revelation of one of the important mechanisms of deliberate humour, i.e. the *intentional* collocation of things that do not normally go together. The patient achieves this end by grinding out enormous numbers of phrases whose combination sometimes turns out to be humorous. It is obviously likely that a computer should one day be able to produce humour by the same mechanism.

6. Lesions in the confusional state

There is a powerful, indeed an overriding, tendency in the literature to attribute the confusional state to 'global disorder' of the brain or to toxic or metabolic causes. The same objections to the concept of global disorder that are also appropriate in other circumstances hold in this case, i.e. these patients clearly have certain areas of dramatic failure with preservation of others. Furthermore, although one most commonly sees confusional states in disorders that *appear* to be global, such as high fever, infection, drug intoxication, metabolic disorders or sensory deprivation, it is not necessarily a correct conclusion that a substance diffused throughout the body is necessarily acting in multiple locations. Indeed, Kurt Goldstein argued many years ago that many of the syndromes produced by drugs are not the results of widespread effects throughout the brain but are the results of local effects. (This may surprise many people who regard Goldstein as a major representative of the anti-localizationist school, but as I have pointed out elsewhere his writings are filled with curious contradictions, and he was in fact a very classical localizer.) Another argument against the view that these states result from global disorder is the fact that certain focal lesions in the nervous system regularly produce confusional states while others do not.

(*a*) *Focal lesions producing confusional states*

Mesulam *et al.* (1976) described the appearance of confusional states with infarctions in the right hemisphere. We were particularly struck by the fact that this was a typical feature of the right parietal infarction, although this had not been referred to as far as we know in the extensive earlier literature on right parietal syndromes. Strangely enough, the older literature on syndromes of right parietal lobe either dealt with vascular lesions large enough to produce a hemiplegia, i.e. lesions extending well beyond the parietal lobe, or dealt with tumours or surgery in this region. In that literature other features of the patients with a very large lesion had been considered and the confusional states had, we think, generally been overlooked. We furthermore realized that before we became aware of this syndrome, we had been, in the days before the computed tomography (c.t.) scan, diagnosing most of these patients as possessing metabolic or toxic disorders, an error easily made in institutions in which delirium tremens was common.

We found in fact that this state could be produced by lesions throughout the middle cerebral artery distribution in the right hemisphere, either parietal or frontal. There was a tendency for these to improve, which probably explained their relative rarity in chronic tumour cases, although we have seen exactly the same syndrome in tumours with rapid growth in the right hemisphere. On the other hand, the syndrome did not occur with lesions in symmetrical locations in the left hemisphere. Even though most of the patients with corresponding left-hemisphere syndromes were aphasic, it was usually easy to show that despite the aphasia they did not manifest the incoherence of the stream of thought or action that characterizes patients with the confusional states.

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We cannot with assurance say that we know all of the locations in which acute lesions produce confusional states, but there is only one location with which I am familiar that seems regularly to produce confusional states with lesions in either hemisphere. Patients with infarctions of the undersurface of the occipital lobe involving either the left or the right side probably projecting forward into the hippocampal region will show confusional states, but I am not familiar with any other location that produces this syndrome regularly on the left side.

7. Implications of the localization of the confusional states

The fact that confusional states occur with such high frequency from right-hemisphere lesions and not from corresponding lesions on the left side is a matter of particular importance both practical and theoretical. Even after publication of our paper in 1976, we believed that the confusional states with right hemisphere lesions were relatively rare. We had been able to diagnose many of them by using nuclear brain scans but it was still true that we saw many patients with the acute onset of confusional states in which the studies were normal. Since the advent of the c.t. scan we have found that these are remarkably common disorders. Indeed in one 2 month period in the Beth Israel Hospital, we found that the confusional state resulting from right-hemisphere infarction without accompanying elementary signs was the most common single vascular lesion seen in consultation on other services in the hospital. It is furthermore of interest that many of these patients did in fact improve; there were, however, many who, despite the lack of obvious evidence of other lesions, persisted in this state.

Space does not permit a full discussion of the theoretical implications of these findings. In 1977 I suggested in my Hughlings Jackson Lecture at The Montreal Neurological Institute that these syndromes were a reflection of an extremely important aspect of cerebral dominance, i.e. the dominance of the right hemisphere for attention. It is in fact my belief that there is a group of right-hemisphere functions that are closely linked precisely because they all relate to functions of monitoring the environment and making decisions as to shifting on the basis of the importance of the monitored stimuli for survival of the self or of the species. The importance of the right hemisphere for attention and emotion, and for the configuration of space, all appear to be possibly related to this function. Furthermore, it appears likely to me that this form of cerebral dominance first appeared in the animal kingdom with right-sided localization many millions of years ago. The recent experiments of Victor Denenberg (1981) at the University of Connecticut on the effects of right hemisphere lesions in rats are consistent with this hypothesis.

I cannot go further into the many possible implications of his system, but I call to your attention a recent paper by Mesulam (1981) in which a detailed review of the anatomical substrates of attention and the clinical implications are presented. That paper furthermore discusses the implications of this system for unilateral neglect, which is not dealt with here.

7. Conclusion

I have presented here only the barest outline of the confusional states. I would stress again their clinical frequency and the remarkable nature of their many manifestations. I would also again point out without detailed discussion that it is easy to see how they could be misdiagnosed as aphasia or memory disorder or psychosis, although once an examiner has become

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skilled in this area this type of error should become less common. I believe that the theoretical importance of the confusional states cannot be overestimated since it is my suspicion that in most subhuman species the attentional systems represent the highest level of cognitive accomplishment, but my guess is that the human attentional systems surpass them in the brilliance of their organization.

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