BRAIN DISORDERS AND LANGUAGE ANALYSIS

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Separate regions of the cortex form complicated systems for the analysis and synthesis of visual, auditory, kinaesthetic and motor stimuli. Focal lesions of the brain produce a break-down in such analysis and synthesis and lead to a secondary disturbance of a whole complex of functions.

Lesions in the left temporal zone cause a break-down in the discrimination and generalisation of sound patterns, and above all in phonemic auditory perception. This in turn affects pronunciation and writing, and also the structure of word-meanings. This failure at the lexical level affects the various parts of a word in different degrees: the roots of words, which carry the more concrete meaning, are lost, while suffixes, with their more abstract meaning, are retained.

Clinical observation of different cases throws light on the distinction between the "communication of events" and the "communication of relations". Lesions in the parietal and parieto-occipital areas produce a failure in dealing with "communications of relations", a failure to combine a number of elements into a single whole. When these lesions extend to the borders of the speech area, they entail a further break-down in operations that require the abstraction of a scheme of reference. "Communication of relations" necessitates precisely this operation and this explains why patients with parieto-occipital lesions are often unable to deal with such communications.

Lesions in the fronto-temporal areas affect the synthesis of successive elements and hence lead to a failure in "propositionizing".

In all cases of parieto-occipital lesion the "regulating" function of speech remains intact. Animal experiments have shown that ablation of the frontal sections of the cortex completely upsets the regulation of the animal's behaviour. In man, frontal lesions interfere with the regulating function of speech without affecting other speech functions.

Observation of aphasia—and more broadly of brain disorders of various kinds—has always provided invaluable material for analysis of the structure of human speech, and hence for a better understanding of some aspects of language structure. What is an indivisible whole in a normal person, and therefore difficult to analyse, in a pathological condition is split up and becomes accessible to analytical investigation, which is always concerned with the isolation of the basic components of a complex whole. The task of isolating such components in human speech and studying the complicated functional systems that directly depend on these components is the immediate purpose of utilizing pathological conditions of the brain for psychological and linguistic analysis.

CORTICAL SYSTEMS AND SPEECH ANALYSIS

Pathological conditions of the brain, and above all those which occur as a result of limited local affections, never produce a direct disintegration of the complex formation of language—morphology, syntax, lexicology or semantics. The time when research workers tried to find in the cerebral cortex special " centres " for understanding or pronunciation of words, for morphological, syntactic or semantic formations as well as for writing, reading and counting, has irrevocably gone. Attempts to correlate *directly* the localised affections of the brain with various aspects of language, as was done by Head, and attempts to describe special forms of verbal, nominal, syntactic and semantic aphasia can have no other value than as the initial summary of clinical observations ; to this must be added an understanding of those dynamic processes that have led to the emergence of the syndrome.

At present, thanks to the results achieved by normal morpho-physiology, by the clinical study of focal lesions and by the combined efforts of physiologists and psychologists in the study of syndromes which arise in localised affections of the brain, the position has radically changed ; research workers can now formulate certain basic theses which make the data of brain pathology incomparably more fruitful for the analysis of normal functions.

It has been established by modern morpho-physiology that separate regions of the cerebral cortex form the most complicated apparatus for specific forms of analysis and synthesis of " exteroceptive " or " proprioceptive " stimuli ; Pavlov quite justifiably called these the " cortical analyser terminals ". Under normal circumstances the function of this apparatus proceeds with sufficient force, balance and mobility of the nervous processes and it guarantees the finest analysis and synthesis of visual, auditory, kinaesthetic or motor stimuli. On the other hand, destruction of the brain tissue within the limits of one section or another, or such changes as can be observed in a limited break-down in the dynamics of the blood supply or of the cerebro-spinal fluid, alter the conditions of its functioning and reduce the strength of the nervous processes within the limits of the given functional system ; the balance of stimulatory and inhibitory processes suffers and their normal mobility is replaced by pathological inertia.

Naturally, under any of these conditions normal function of the given " analyser " is disturbed, the ability to differentiate stimuli in adjacent systems loses its precision, and the whole process of analysis and synthesis within the limits of the modality with which the particular cortical system is concerned, acquires an imperfect and sometimes even a pathological character. This disturbance of normal processes of analysis and synthesis within the limits of a given functional system (visual, auditory, kinaesthetic or motor) is *a direct primary result of every focal lesion of the cortex.*

However, this immediate, primary effect of focal lesions never remains an isolated one. The real units of brain function are those most complicated systems of temporal connections which lead to the well-known forms of adaptive activity and which in a human being assume the form of objective activity—active or passive speech, writing or reading, counting or the solution of cognitive problems. Every one of the very complicated functional systems that have been formed in the history of social development includes in its composition many functional components and can normally be realized only in the presence of a number of physiological conditions. Naturally, in order to distinguish speech sounds a precise acoustico-articulatory analysis is necessary, just as the articulation of any word requires the conservation of those kinaesthetic impulses that alone make possible the distinction between similar articulations. It is perfectly clear therefore that when the action of one analyser which takes part in the realization of any of these activities is broken down, *then normal existence of the functional system as a whole becomes impossible, and there is a selective pathological effect on all that most closely depends on normal action of a given analyser.* This break-down, which occurs as the result of a primary disturbance of the action of one of the analysers, is *the secondary or systemic effect of the given lesion.* These secondary or systemic effects of the partial affection also constitute the basic content of the pathology of localized disturbances of cortical function. These effects include the symptoms of aphasia agnosia or apraxia, the study of which for analysing the structure of the speech processes is the main subject of this article.

It would be wrong, however, to suppose that the complex speech system becomes equally disintegrated with the primary break-down of different components. The various components of speech activity do not occupy an equal place in the complicated functional system of speech ; auditory analysis and synthesis, the kinaesthetic differentiations required for precise articulation, analysis and synthesis of space and time relations —all this is necessary, but in different degrees, for the hearing and understanding of speech, for the active pronunciation of sound or words, for writing or reading. It is quite natural therefore that a defect in the action of one analyser or another, arising as a result of a focal lesion of the brain, inevitably leads to a secondary disturbance of a whole *complex of functions,* normal realization of which depends on its conservation ; therefore the disintegration of the speech system, which arises as a result of the primary disturbance of each of these physiological functions, will vary in character. Just as an experienced cardiologist can, according to the character of the disturbance in heart function, draw conclusions about the place in which the damage has occurred, so an experienced neurologist who is studying the character of speech disorders can with confidence deduce which of the primary defects lies at its base. And it is precisely because of this that the pathological method is so valuable for the discovery of those hidden peculiarities of the structure of speech and of the mechanisms on which language is based, and the analysis of which has inevitably escaped objective investigation.

TEMPORAL ZONE LESIONS AND DISINTEGRATION OF PHONEMIC ORGANIZATION OF SPEECH

Clinicians are well acquainted with cases where an affection of the postero-superior sections of the left temporal zone (in the right-handed patient), the so-called Wernicke area, leads to a break-down in the comprehension of speech ; to the patient, words begin to sound like inarticulate noises and their meaning is no longer taken in. Such break-downs, as the outstanding linguist, Jakobson, has so aptly remarked, lead to disturbances of the elementary sound code of speech, and at the same time lead to a break-down in the normal designation of objects, in the process of writing and to peculiar disturbances in thinking. These disturbances of speech are widely known under the name of " sensory " aphasia, but the mechanisms which lead to this condition continue to provoke lively arguments. It has remained obscure precisely which of the primary break-downs lead to such disturbances of speech, whether it is a " defect of hearing " or a " defect of thinking ", and it is difficult to explain the remarkable diversity of speech manifestations that are lost in such cases.

Analysis of a considerable number of cases of left temporal lesions, carried out by Soviet clinicians, physiologists and psychologists, during the last decades, offers a closer approach to the solution of some of these problems. Investigations have shown that a lesion of the area in which we are interested, which is a part of the cortical end of the acoustic analyser system, does not produce (as was thought in classical neurology) any loss of hearing for any part of the frequency range, but inevitably leads to *damage in the process of differentiation and generalization of sounds, in other words, in the processes of sound analysis and synthesis.* This is evident from the fact that such patients easily form conditioned reflexes in response to sounds, but experience considerable difficulty when they are faced with the problem of differentiating complex groups of sounds, and these difficulties are very great both in the attempt to form differentiated reactions to chords which differ from each other by the presence of different components, and especially in attempts to work out a distinction between two series, in which sounds are arranged in different sequence (ABCD and ACDB) (Traugott, 1956, Babenkova, 1954, Kabelyanskaya, 1955, and others). It is characteristic that a corresponding differentiation of visual complexes remains in these cases relatively intact.

It seems, however, the most essential point is that this break-down of sound analysis and synthesis does not remain within the limits of elementary sound complexes, but is seen particularly clearly in the differentiation of similar phonemes ; a break-down in phonemic auditory perception may be recognized with every justification as a basic symptom of a lesion in the region we are interested in.

As a result of work, the foundations of which were laid in the modern phonetic theory of Baudouin de Courtenay (1882), Shcherba (1912), Trubetzkoy (1939) and Jakobson (1956), it has become clear that the phonetic structure of language depends on a system of sound oppositions, which are variously arranged in different languages,

but in which invariably one of the phonetic features (voice—voicelessness, accent—absence of accent, palatalization—absence of palatalization, etc.) plays a basic part, acting as a signal that differentiates meaning. The discrimination of these phonetic features, produced in the sound-complex by means of a variation in the articulatory processes, provides the mechanisms necessary for speech perception.

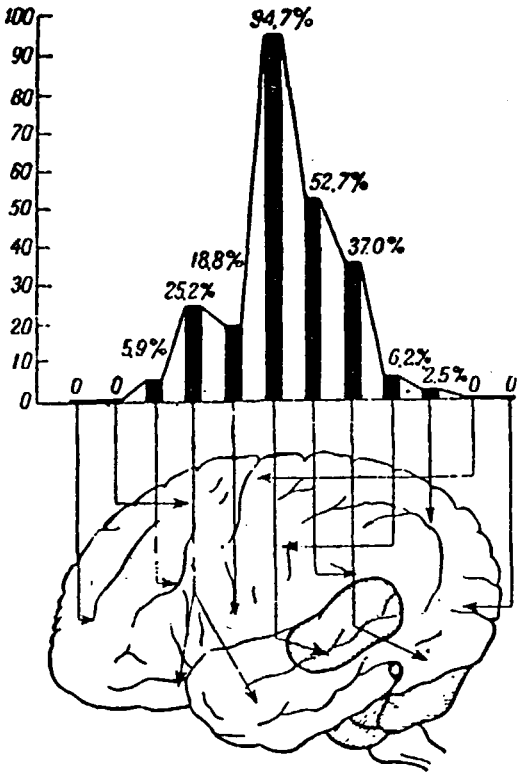

Fig. 1. Disintegration of phonemic acoustic perception in variously located brain damage (the columns show the percentage of break-downs in the total number of patients with corresponding location of the affection: each group comprises 60 - 90 cases).

It is these systems of discrimination that are broken down in cases of lesions of the postero-superior sections of the temporal area of the dominant hemisphere, perhaps because this apparatus stands in the closest functional and morphological relation to the inferior sections of the kinaesthetic and motor area of the cortex, which play a direct part in the act of articulation, and this part of the brain can be conceived of only as forming a single auditory-articulatory system.

The breakdown of phonemic auditory perception is a fundamental and persistent symptom accompanying lesions of the left temporal area, and may be easily revealed by simple experiments, such as asking the patient to repeat similar (but opposed) phonemes (e.g. /b - p, t - d, z - s/, etc.) or attempting to elicit from him definite differentiated reactions (e.g. raising the hand in response to the voiced /b/ and not raising it in response to the voiceless /p/). Fig. 1 gives a summary of results obtained during the war from the analysis of more than 800 cases of bullet-wounds of the brain, and it shows that the breakdown in phonemic auditory perception accompanies only lesions of the postero-superior sections of the left temporal area (or of parts adjoining them, in which case the break-down is a secondary effect), and is not typical of lesions of other sections of the brain. Further observations have made it possible to ascertain that this remains the most persistent symptom in residual phases of traumatic illness, is one of the early indications of the growth of a tumour in this area, and can be disclosed through stimulation by means of special sensitized probes even in the most serious cases of these lesions.

The breakdown of phonemic auditory perception at once produces a series of *secondary disorders* : it inevitably leads to a break-down in the language system of all those formations in which it took part and which require precise phonemic auditory perception as an indispensable condition of their normal functioning.

The break-down of precise phonetic analysis and synthesis leads above all to a break-down in the *pronunciation of words*, especially where this pronunciation does not have an automatic character. It is sufficient to ask the patient to repeat a word which is new and phonetically difficult in order to ascertain this. It leads to particularly severe break-downs in *writing*, even when the ability to copy a given text without difficulty is preserved ; such a patient proves to be incapable of writing any word at dictation or spontaneously (again, provided it is not sufficiently automatized), has difficulty in distinguishing its component sounds, and substitutes similar but ' opposed ' phonemes.

Primary break-down of phonemic auditory perception leads, however, to more extensive consequences, exerting its own peculiar effect on the structure of the *meanings* of words, and essentially breaking down the language vocabulary formerly possessed by the patient. A patient with break-down of phonemic analysis loses the ability to take in words and to differentiate their meanings. If /telo/ and /delo/, /totʃka/ and /dotʃka/ come to sound similar, the meanings of these words cease to be clearly differentiated ; if words with a complicated phonetic composition (e.g. with a consonant cluster) become for the patient insufficiently articulated groups, their meaning naturally ceases to be marked off from the meaning of other words, the superficial phonetic similarity, which is over-ruled by the precise phonemic structure of normal speech, is given free rein and the patient tends to class together words which have something in common in their sound, but which have never before been put into the same category of meaning. Thus /otʃen/ and /osen/, /kolos/, /golos/ and /xolost/, which were never formerly confused, easily begin to replace each other, and the basic meaning-structure of the patient's vocabulary disintegrates,

giving way to phonetic connections no longer reduced to an orderly system. The disintegration of the phonemic structure of language inevitably leads to a break-down in its lexical structure ; the break-down of the understanding of speech appears as a result not of intellectual disorder, but of the disintegration of the complex auditory function and it produces a failure of the power to use the systematized language code.

An essential fact is that the disintegration of the lexical structure of language caused by the break-down of phonemic auditory perception does not affect all morphological elements of a word to the same degree. Observations by Bein (1950) in recent years show that such patients lose the power to understand the roots of words, of which there are a great many in each language and for the precise understanding of which it is specially indispensable to differentiate them from many other complexes, phonetically similar but having a different meaning ; on the other hand, suffixes of words, which are relatively few in a language and do not have such a multiplicity of possible phonetic connections, ordinarily remain considerably more comprehensible. Hence arises the paradoxical and apparently little-understood fact—so contrary to the widely held belief that in the pathology of these cases invariably those elements are earliest broken down which were last formed—that patients with the form of aphasia described lose the concrete meaning (attached to the root of the word) and retain abstract meanings, attached to such suffixes of abstract state, as *-ost (vidim-ost)* or *-ie (sostoyan-ie, obrazovan-ie)* in Russian, *-heit (Treu-heit)* or *-keit (Nachbar-keit)* in German, *-ance (vigilance)* in English or French, and so on.

The potential retention of abstract terms in patients with such disorders,[1] and the associated relative retention of abstract ideas, is one of the most interesting of those phenomena that allow a close approach to the analysis of formations which arose first on the basis of vocalic speech, but which, with the development of human mentation, have begun to take on a relative independence.

Communication of Events and Communication of Relations

There is no doubt that the careful investigation of these phenomena which arise as a result of such disorders opens wide avenues for the analysis of important problems on the borders of phonetics and morphology on the one hand and the psychology of speech processes on the other. Information which a human being receives by means of language is not confined to the designation of single objects ; the most significant

[1] *The thesis just mentioned retains, of course, its significance only in the case of break-down of the phonemic structure of speech in adults who have already formed the semantic system of language. Early break-down (or underdevelopment) of phonemic hearing in a child, in whom the semantic system of language has not yet been formed, leads to considerably more general and serious disorders of mentation. This means only that in describing various forms of secondary disorder, which are the result of a partial affection, one must always keep in mind at what genetic stage this break-down took place and what system it found already in existence. This idea, already expressed by Vygotsky (1956), has a fundamental significance for evaluation of the systemic effect of disease, but a consideration of it is beyond the scope of this article*

information comes from *systems of words* or from whole communications. Since the time of Svedelius (1897) it has been customary to divide these communications into communication of events (of the type : " A dog bit the boy ") and communication of relations (of the type " Socrates is a man " or " The circle is drawn under the square " or " This is the father's brother "). If the first type is expressed in European languages mostly by means of the inflexion system, the second type can be expressed both with the help of the most abstract forms of case relationship or with the help of special types of preposition or conjunction.

Linguistic analysis has always indicated a difference in the degree of abstraction in the two kinds of communication and the fact that in each of them the object, the visual perception and abstract thinking do not participate to the same degree. However, in spite of the facts which indicate that they originated at different epochs and that they have different logico-grammatical structures, the distinction between them has remained relatively formal.

In this problem of isolating the class of linguistic formations represented in the " communication of relations " and in analysing peculiarities of their inner structure, pathology can offer considerable help. Already at the time of Head (1926), Gelb and Goldstein (1924), Van Woerkom (1925), Boumann and Grünbaum (1925) and of a number of other more specialised studies, it was noted that patients with disorders of the postero-parietal and parieto-occipital sections of the dominant left hemisphere show characteristic disabilities : although still able to understand everyday speech, they are incapable of understanding the meaning of complicated logico-grammatical combinations, which express certain abstract relationships. At the same time these patients show considerable difficulty in operating with spatial relations of objects ; they lose their ability to operate with mathematical categories, easily confuse arithmetical symbols and find themselves in great difficulties when confronted with the necessity of analysing numbers in structural arrangements. All these facts have been confirmed by research workers, who have given a closer description of the " parietal syndrome " (Konrad, 1932, Zucker, 1933, Klein, 1931, Gerstmann, 1932, Critchley, 1953, Hécaen, 1953, Zangwill, 1957, and others). The description of symptoms occurring with parietal affections leads us to believe that with the help of pathology we shall be able to isolate what is *specific* to the complex form—the " communication of relations ". However, the theoretical interpretation and explanation of these facts has confronted research workers with considerable difficulties.

Some authors, adhering to the so-called " noëtic trend " (Goldstein, 1948, Van Woerkom, 1925, Grünbaum, 1925, and others) and in actual fact continuing the line of Pierre Marie, have been inclined to see behind these symptoms a break-down of the " general function of the intellect " or of " categorical thinking " (a view which explained very little and has rather obstructed the way to further research). Other authors, with a more analytical attitude (Konrad, Zucker, Critchley, and Zangwill), have not been satisfied with these somewhat too general principles and have begun to look for a more specific brain mechanism as the basis of these disabilities.

The solution of the problem has been materially advanced by observations that have stated the facts more precisely and have allowed us to make a step forward towards an adequate explanation of this most complicated syndrome.

A careful analysis of patients with limited lesions of the inferior parietal (or parieto-occipital) area has shown first of all that in these cases by no means all the forms of speech activity are broken down, and by no means all the forms of abstract thinking and behaviour. These patients, while still able to understand everyday speech denoting events, also preserve abstract notions which express inner psychological states and moral values, as well as some abstract categories. They begin however to experience considerable difficulties every time they have to analyse a complicated figure and to co-ordinate its details into one whole, or to operate with numbers in structural arrangements ; they confuse spatial direction when examining numbers of more than one digit and—a fact that is of particular interest for the problems with which we are directly concerned—they are nonplussed every time they are faced with a " communication of relations ".

All this has compelled us to reject the global and clearly incorrect assertion of the " general lowering of the intellect " or " the loss of categorical thinking ", supposedly resulting from these lesions, and, following our chosen direction, to seek the primary break-down of the higher nervous processes, which arises in the given local affection and which, as a secondary systemic effect, leads to the disorders just described.

Already experiments on animals have shown that lesions of the posterior sections of the cortex and especially of those areas which have acquired the name of " posterior intrinsic areas " (Rose, 1952, Pribram, 1957) break down the ability to react differentially to complex configurations of signs and considerably restrict the information that can be received by the animals ; the work of Pavlov and his pupils with extirpations of the posterior sections of the cortex defined more accurately the physiological mechanisms which are at the base of these break-downs, and showed to what extent one set of functional systems may suffer a persistent heightening of sensitivity to stimulation whilst another distinct set of systems suffers a decrease in sensitivity.

Such break-downs in the processes forming the complicated systems of discrimination and occurring as a result of lesions of the parieto-occipital sections of the cortex have been described in great detail in man. Also, the basic disorder which occurs in these cases is illustrated by the phenomena of " simultaneous agnosia ", widely known in clinical practice (and described by Wolpert, 1924, and Bálint, 1909) as well as by the phenomena of astereognosis which are similar in structure. The fact that patients lose their ability to " combine details into a coherent whole " (Head), that there is a loss of synoptic function, of the ability to " see elements in a single structure " (Goldstein) or to " transform the act of sequential observation into simultaneous observation " (Pötzl), all this only reflects those neurodynamic shifts which in these cases cause a break-down in the systemic activity of the cortex so that the patient, as Pavlov said, " finds himself in a condition to deal with only one point of stimulation at a time while the rest are inhibited ".

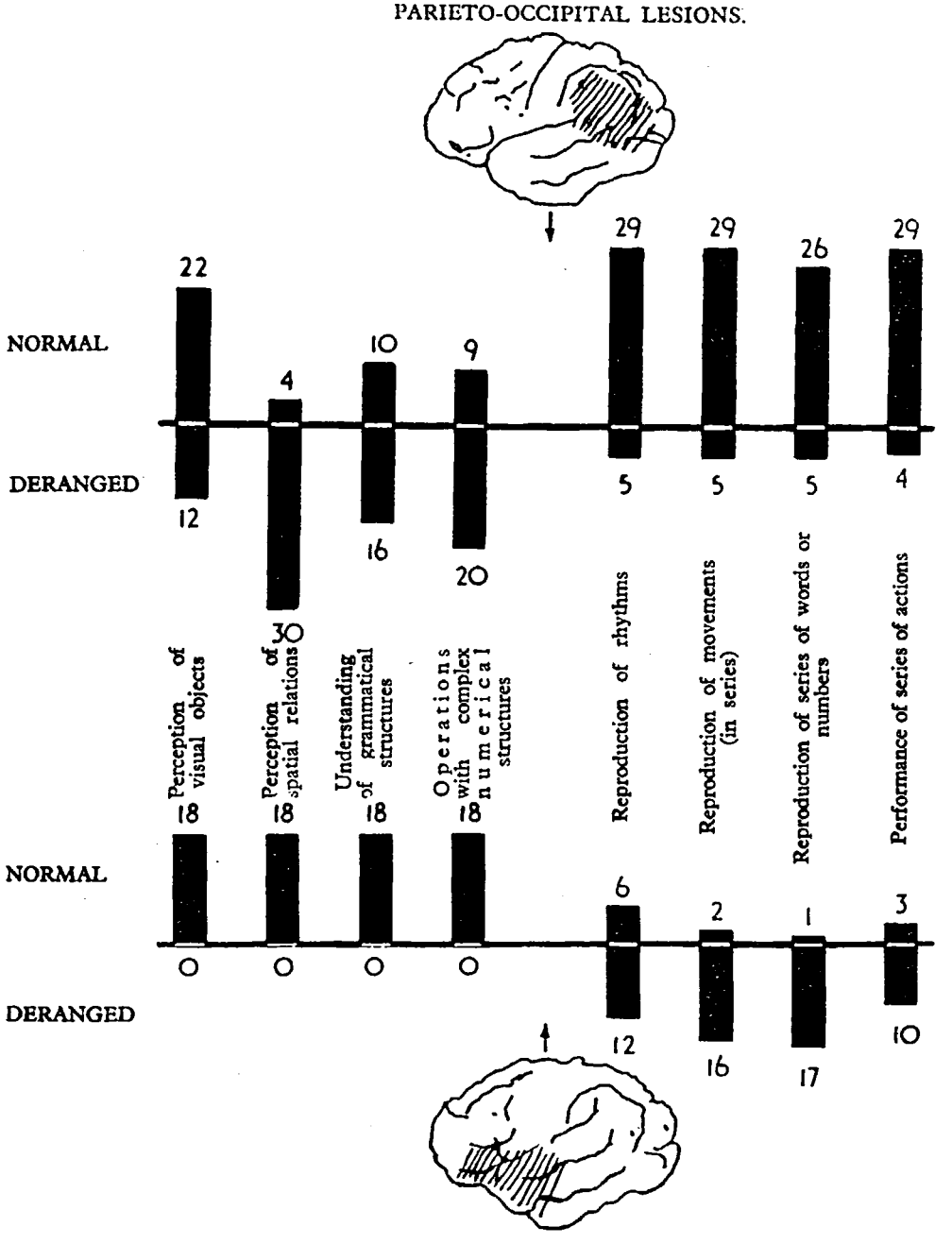

Fig 2. Disintegration of the operations connected with simultaneous and successive synthesis in cases of affection of the posterior (parieto-occipital) and anterior (fronto-temporal) sections of the hemisphere The columns show the number of cases in which a given operation could be carried out (upper columns) or could not be carried out (lower columns).

We have had occasion to describe a patient whose bi-lateral lesion of the parieto-occipital area of the cortex led to his inability to combine two details simultaneously ; in a tachistoscope he could not perceive two letters at once, nor could he make a point in the centre of a cross or circle : one visual impression inductively inhibited the other and the simplest visual synthesis remained impossible for him.

Such a break-down of simultaneous synthesis can be quite justifiably regarded as the physiological basis of functional disorders, occurring in lesions of the parieto-occipital areas of the brain. However, if the lesion goes beyond the limits of the parieto-occipital areas of the cortex and reaches the border of the speech area, it may produce disorders which go far beyond the limits of the visual realm. They inevitably lead to a break-down of the more complicated mnemic operations, connected with abstraction of one signal and the synthesis of a series of elements in accordance with this abstracted signal. They also lead inevitably to a situation where *operations which use a definite complex code and which are linked by means of this code with the intellectual act become impossible.*

As has been shown by special research, affections of the parieto-occipital areas of the cortex lead precisely to the inability to isolate one signal and to produce a stable system of heightened sensitivity to stimulation whilst inhibiting irrelevant systems. They produce in the patients a significant break-down in generalisation from visual figures which are similar in one parameter (e.g., colour, shape, etc.) and different in others (Kok, 1957). Similar defects occur in these patients in their evaluation of space relations (Konrad, Zucker, Head, Critchley, Zangwill), in operations connected with counting off elements in space (compare finger agnosia and Gerstmann's syndrome) and finally in arithmetical operations (especially in those connected with the analysis of numbers in structural arrangement) and counting, especially of numbers exceeding 10. These operations always require the abstraction of a scheme of reference and comparison of a whole complex of connections with this scheme.

In all these cases, where the problem requires such complicated operations, affections of the parieto-occipital systems lead inevitably to their disintegration, at the same time conserving intact those operations which do not require such simultaneous observation of details and which can be realised by means of successive synthesis such as, for example, the beating out of rhythms, the reproduction of a series of successive movements, of the words of a poem, etc. On the other hand, when the fronto-temporal systems are affected, with the analysis of which we have dealt elsewhere in detail (Luria, 1957a), operations associated with simultaneous synthesis remain completely intact, whilst operations which require a successive synthesis of elements (auditory or motor in the first place) into one complete structure, suffer considerably (see Fig. 2).

The above statement allows us to turn directly to the questions in which we are interested in this paper. We have already mentioned the two forms of language construction, which some linguists call " communication of events " and " communication of relations " ; now we can return to their analysis from the new standpoint which has just been classified.

" Communication of events " in its simplest and purest form (of the type " A house is burning ", " A dog bit a boy ") depends on well-consolidated sequences of verbal relationships and does not require from the hearer a preliminary abstraction of one of the signals used in them, with the subsequent establishment of a complicated system of relations. Only in those cases where, as a result of inversion (e.g. " A boy was bitten by a dog "), the usual word order is affected and the order of communicated events ceases to coincide with the word order in a sentence,[1] does the preliminary analysis of construction become necessary ; isolation and comparison of its separate elements and comprehension of this construction on the basis of " the combination of isolated details into a coherent whole " corresponds this time to the logico-grammatical code of the language.

The very opposite takes place in the understanding of a " communication of relations ". Even the simplest " communication of relations " (if it is not of the most common type) is a complicated and peculiar problem, which necessitates a comparison of two elements together with the extraction of the basic signal and subsequent synthesis of the two elements into a specific structure.

A typical example of such a system is the construction " father's brother " and the opposite construction " brother's father ". In both cases it concerns two objects, described as " brother " and " father ". The construction as a whole does not refer to these objects, but to a third one, resulting from their logical combination : " uncle " in the first and " father " (defined from another, new relationship) in the second. In order to grasp this construction, which has developed relatively late, it is not sufficient simply to perceive two isolated designations ; it is necessary to isolate the basic symbol (" father ") and to grasp the meaning of the second symbol (" brother's "), having as a starting point its relation to the first. In some languages (e.g. Russian), which show these relations by means of the genitive attributive, it is necessary to carry out an operation of abstraction from the substantive meaning of the noun which is in the genitive and to convert it, according to its meaning, into a qualitative word (father's brother = paternal brother).

A completely analogous psychological construction is that of the communication of spatial relations expressed by means of a preposition, e.g. " a circle under a triangle " and its opposite " a triangle under a circle ". In this case the simple designation of the two elements merely begins, but does not complete, the formation of the complex idea ; for the understanding of the meaning of this construction it is also necessary to distinguish the basic object (e.g. " triangle ") and to evaluate the spatial relation of the second object (" circle ") to the first. A similar construction is that of communication of temporal relations (e.g. " summer following the spring " or " spring following the summer "), instrumental relations (e.g. " the earth is lighted by the sun " or " the

[1] *In the case of separated and subordinate clauses ; the following sentence may serve as an example of such a construction : To the school where Peter is studying, a woman came from the factory to talk about the preparations for the holiday.*

sun is lighted by the earth "), the correct forms of which may be established only after an analogous operation of distinguishing the basic designation, and of establishing the meaning of the second object, and then in turn of establishing the meaning of the whole construction from the relation which has been analysed.

After what has been said it becomes quite clear that these constructions which are very complex in form and came into being relatively late [1] are very vulnerable, and inevitably disintegrate when the basic condition, indispensable for their understanding, is unattainable as a result of the break-down of complex " simultaneous synthesis " and of the ability to combine isolated elements into a single analytic " unit ".

This is why patients with parieto-occipital lesions, especially those located on the border of the " speech zones of the cortex ", are often incapable of coping even with apparently simple " communications of relations ", are baffled by the task of " drawing a square under a circle " (ordinarily carrying out the task in an agrammatical way in the order in which the words are spoken and hence drawing a square, then under it a circle), and prove to be completely incapable of distinguishing between the two constructions " father's brother " and " brother's father ", declaring that in both cases the brother and father are spoken of and consequently the constructions are identical ; and readily accept the construction " the sun is lighted by the earth," in which the habitual order of words in an active construction is agrammatically adopted as being the correct one. This symptom, appearing distinctly in cases where the affection damages the most complex and most recently formed zones of the parieto-occipital region at its border with the temporal region, constitutes a basic symptom of so-called " semantic aphasia ". For the analysis of this condition, problems in understanding the simplest logico-grammatical relations occupy the same place that problems in the differentiation of opposed phonemes occupy in the analysis of temporal " acoustic aphasia ".

The close study of the changes that take place, in the cases we have considered, in the employment of the most complex codes of language (the phonetic code in one, the semantic code in the other case) consequently permits the use of focal lesions of the brain as a means for the analysis of complex linguistic phenomena and for the analysis of those functional formations which, without this method, would remain difficult of access to pathological analysis.

[1] *In some languages the emergence of such complex flexional or prepositional constructions goes back only as far as the XIVth-XVth centuries and in earlier records and documents such constructions are replaced by simpler ones, not requiring any complex analytic-synthetic effort. Typical examples of such simplification with the replacement of complex forms of government by simple paratactic constructions are the Greek : " They escaped the strength and arms of the Achaeans (instead of " the strength of the Achaeans' arms.") (Odyssey, VIII, 134) ; the German " mit Leidschaft und Liebe " (instead of " mit Leidschaft der Liebe ") (Nibelungenlied, 1148,3) ; and the English " For yonder I hear Sir Guy's horn blow and (for 'which') has slain Robin Hood " (Ballad of Robin Hood).*

The effect of frontal lesions on speech

We have surveyed the analysis of those break-downs in the complicated system of linguistic constructions caused by affections of the parieto-occipital systems of the brain which lead directly to the disintegration of simultaneous synthesis and to the break-down in the act of "combining isolated details into a single whole" which Head so rightly pointed out in his time.

The logic of our exposition requires us now to turn to disturbances of the speech structures which arise in cases of disintegration in another important function, which as all the data show (cf. Luria, 1957a), is provided for, in the first place, by the anterior fronto-temporal sections of the cortex, and which results in the *synthesis of successive elements into a single continuous series* or "dynamic system". Such disturbances of sequential synthesis and of acoustico-motor sequences directly linked with them, or, as they are often termed clinically, "kinetic patterns", do not remain without effect on the speech systems also. But in this case, as we have shown elsewhere (Luria, 1947, chap. 4) the disintegration of complex speech formations proceeds along a completely different course; the patient, revealing no noticeable defects in the distinguishing of the phonetic elements of verbal speech or in the grasping of logico-grammatical relations in language, begins to display noticeable break-downs in smooth transition from subject to predicate, and consequently, in the realization of that "propositionizing" of which in his time Hughlings Jackson spoke so fully and in such detail. This break-down of sequential synthesis does not destroy single systems of stimulation but impedes the easy switching off of these stimulations and the transition from one system of innervation to another (in a pure form this break-down is seen in the so-called "pre-motor syndrome"). As a result of such disturbances there is a secondary affection of *internal speech,* which—as has been correctly affirmed by a number of psychologists— is predicative speech turned inwards (Vygotsky 1956) and the presence of which is absolutely indispensable for fluent predicative propositionizing. It is these affections which eventually lead to the appearance of that exceptionally interesting phenomenon which is widely known in clinical literature as "telegraphic style," and which Jakobson with full justification considers as a break-down of *contextual speech,* in many ways opposite to the break-down of the "*code of language*" (phonetic or logico-grammatical), with which we were concerned above. However, the limits of this paper do not allow us to concern ourselves in greater detail with this peculiar form of disorder, or, what is most important, to throw light on the primary neurodynamic conditions of its appearance in the same way as we have attempted to do with respect to the forms of speech disturbance dealt with earlier.

We shall therefore cut short our exposition and pass to the consideration of those forms of the pathology of speech which in many respects have special interest and which have not received the attention they merit. Up to now we have been concerned with the analysis of information provided by focal lesions of the brain for the analysis of the structure of the speech processes and in particular for the intensive study of the phonetic and morphological, semantic and syntactic side of speech. However, apart

from these essential aspects of the speech process, which make possible the use of language as a means of communication and an instrument of thought, there is still another essential function of speech, which has received even scantier attention from linguists and psychologists. We have in mind the *regulating* function of speech, which, as we shall show below, remains relatively intact in the cases described above and which requires close consideration.

When an adult addresses some order to a child, he calls into action in the child a system of governing connections, which direct all its subsequent behaviour and inhibit all irrelevant actions. The speech of the adult here regulates the behaviour of the child. This regulating effect, which the speech of the adult exerts on the child's behaviour, eventually becomes the source of complex new functional formations. In acquiring his own speech, at first external and later internal, the child begins to use it not only as an instrument of communication and thought, but as a *means of regulating his own behaviour.* The child's own speech, which helps him in orientating himself in his environment, and creating a system of connections in which he reflects reality and formulates his desires, enables him to map out his own behaviour and to regulate the course of his activity. Research carried out in recent years and treated by us in another place (Luria, 1957b) has made it possible to show what a complex path is traversed by the formation of this regulating function of speech before it becomes capable not only of setting in motion known and already consolidated actions, but of locking in the governing system of connections and checking all irrelevant actions, which do not relate to the fulfilment of the task formulated in speech. There is no doubt whatever that all the highest functional formations with which psychology is concerned —the accomplishing of conscious, purposive action, systematic active thought, voluntary memory—all these are in greater or less degree linked with the regulating function of speech. In all these cases external (or more often internal) speech locks in an existing system of connections, which in normal behaviour become dominant, and which define the course of all the subsequent actions of the person, acquiring sometimes—as, for instance, was the case with Giordano Bruno—a strength which considerably exceeds the strength of vital instincts.

What does the study of pathological states of the brain contribute to the analysis of this very important but still little-studied regulating function of speech? Is that function broken down in equal degree in various brain lesions, or can we distinguish particular brain-systems, the preservation of which is absolutely indispensable for the regulating effect of speech on behaviour?

The cases of focal brain lesions, which we have analysed above, broke down the phonetic and lexical, semantic and syntactic side of speech, but did not yet lead to a distinct break-down of its regulating function. Patients suffering from the defects described above readily executed the doctor's instructions, formulated in speech, concentrated for a considerable time on carrying out the tasks he set and frequently revealed an exceptional persistence in the task of compensating for their defects, without which the restoration of the broken-down functions would be impossible. Special

experiments (as yet unpublished), carried out recently, have shown that in all these cases the patient's speech, broken down in the phonetic or grammatical respect, continues to preserve its determining, directing role, ensuring at the same time intelligently directed behaviour by the patient.

In order to study the pathology of the regulating function of speech, it is consequently indispensable to go beyond the limits of the forms of speech disorder studied by us, and as we shall see below, in general beyond the limits of what is clinically known as " aphasia ".

For the successful solution of the question that interests us we should for a short time leave the description of speech disorders and consider the facts revealed by contemporary neurophysiology and psychology in studying the brain-mechanisms regulating the active behaviour of animals.

All contemporary work which has studied the peculiarities of animal behaviour after the removal of separate parts of the brain, beginning with the work of Franz (1907), Bianchi (1921) and Pavlov and ending with the latest researches of Fulton (1945), Pribram (1957) and Anokhin (1949)—despite the divergence in the positions from which they started—lead to one essential fact. Ablation of the *posterior sections of the major hemispheres* causes in the animal a break-down of accuracy in the operation of separate analysers, which leads to a defect in particular types of differentiation and the restriction of corresponding information coming from the environment, but never leads to a break-down of the general regulation of the animal's behaviour, which remains just as expedient as before. On the other hand, ablation of the *frontal sections of the major hemispheres,* though not causing any noticeable break-down in the action of separate parts of the exteroceptive apparatus, sharply alters the whole behaviour of the animal: it ceases to distinguish the essential in a situation, to assess its own experience, it reacts identically to those stimuli which are important for life and to those which are indifferent ; it continues to make movements which have become senseless after it has found the bait it was looking for (as was the case in the experiments of Anokhin, Pribram and Shustin). Evidently it does not assess in its behaviour the general situation and the effect of previous experience. All this justified Pribram in saying that the frontal sections of the brain have special functions, determining the expediency (" utility function "), the selective character of behaviour (" preference behaviour "), and allowed Anokhin to come to the conclusion that their function, closely connected with the regulation of motor behaviour, consists in the creation of a complex " pre-initiatory afferentation ", which includes signals concerning the successful completion of an act, and makes possible the realization of preference behaviour.

The part played by the frontal sections of the brain in the regulation of complex forms of preference behaviour is thus shown to be indisputable, and even if the physiological mechanisms which ensure this regulation remain up to the present obscure, the distinguishing of this function of the frontal portions should be considered among

the important achievements of neurological science.[1]

If the purposive behaviour of an animal is determined by that " pre-initiatory afferentation ", which in fact regulates all its subsequent activity, then in a human being such " pre-initiatory afferentation " consists in a system of governing connections, formed by means of *speech*. Therefore it is natural that in cases of affections of the frontal systems in man, there should be a break-down not only of the system of synthetic " pre-initiatory afferentations " which determine his subsequent behaviour, but in the first place a break-down of the system of " pre-initiatory afferentations " created on the basis of speech—in other words, a break-down of the regulating function of speech connections.

Protracted research into the disintegration of the structure of behaviour in patients with lesions of the frontal portions of the brain, carried out by us together with a number of colleagues (Filippycheva, 1952, Meshcheryakov, 1953, Ivanova, 1953, etc.) have made it possible to describe the peculiar picture of disorders arising in these cases, which have never been classed as aphasia but which may be understood essentially as break-downs in the regulating function of speech.

As a rule, we do not observe, in patients with lesions of the frontal portions of the brain (however severe and massive these affections may be) any noticeable break-downs whatever in the structure of speech processes: the phonetic system and vocabulary, the semantic system and the grammar of speech of these patients proves as a rule to be completely intact both in its receptive and its expressive part. It is only in patients whose brain affection is situated in the postero-inferior sections of the left frontal area adjoining Broca's area that we observe a certain inactivity in speech, a break-down of monologue speech with preservation of responsive (dialogue) speech, which we have had occasion to describe elsewhere as a symptom of " frontal aphasia " (Luria, 1947).

And yet, despite its superficial intactness in these patients, the regulating function of speech proves to be severely disintegrated. This disintegration is revealed in patients with severe (and particularly bilateral) lesions of the frontal areas either by simple observation or in experiments involving their carrying out simple instructions. In many—the most severe—cases, such patients prove unable to carry out even the simplest instructions ; though they may repeat in an echolalic way the experimenter's order " Raise your hand ", they nevertheless make no attempt whatever to perform the required action. Sometimes the words of the experimenter may set in motion the

[1] *It is interesting to note that Pavlov stresses the distinction of the functions of the occipital and frontal sections of the brain. " If you cut out the whole occipital part of the cerebral hemispheres of a dog," he writes, " you will get an animal which is in general quite normal.... It wags its tail when you stroke it. It will also show its pleasure, by sniffing in recognition at you. But such an animal will be unable to react to you if you stand at a distance.... Such a dog has very little use from its eyes and ears, but for the rest, is completely normal. But if you cut out the frontal part of the cerebral hemispheres.... then you will have an obviously abnormal animal. It has no correct reaction to other dogs, nor to food, nor in general to surrounding objects. It is a completely ruined animal, evidently left with none of the signs of purposive behaviour ". I. P. Pavlov, Coll. Wks., III, 175-6.*

action of the patient, but he proves to be powerless to stop it or to change the action once started to another. If such a patient is given the task of drawing a circle, he begins to carry this out, but then, submitting to the inertia of the stimulus in the motor regions of the cortex, he proves unable either to cease this movement or to change over to another action ; when asked to draw a triangle, he correctly repeats this instruction, but continues through inertia to draw a circle. The inertia of an act once initiated and the weakness of the regulating effect of speech is displayed in experiments with the carrying out of a complex of instructions ; in response to the request to draw a triangle, a circle and two squares, the patient begins to draw a number of triangles or a single triangle, accompanied by several circles, although in some cases the patient remains capable of repeating the instruction.

Particularly distinct data, indicating a significant break-down of the regulating function of speech, were gathered from these patients in special experiments, in which the speech of the experimenter did not set in motion the old, well-established connection, but locked in a new conditioned connection. If, as was shown by Meshcheryakov and Ivanova, such a patient was asked, in response to a flashing light, to press on a rubber bulb, or in response to a red light to press with the right hand, but in response to a blue light to press with the left hand, these instructions continued to regulate his action only for a very brief period, and the carrying out of the instruction would very soon cease, often being replaced by an inert repetition of stereotyped pressures, which would completely lose their relation to the preliminary signal and were carried out independently of it. Only by changing over to a prolonged insistence on the instruction by means of a frequent repetition of the command (" Press ! " or " Don't press ! ") after each preliminary signal, was it possible to produce the formation of the required conditioned connection, but even this survived only a very short time, easily disintegrating in the course of the experiment and being replaced by persistent pressures which were not timed to the signal.

The break-down of the regulating role of instruction by speech appears most clearly in experiments with delayed reaction. When patients with a massive lesion of the frontal areas were asked to raise their hand in response to a knock produced 15-20 seconds after the instruction, they did so, but in cases of the most severe affection the regulating action of the instruction was broken down to such an extent that the movement set in motion by the instruction—the raising of the hand—was replaced by an imitative movement ; the patient would reproduce the movement of the experimenter by knocking beside the place where the experimenter knocked. However, when such a patient was given the instruction, requiring the production of a reaction in accordance with speech connections already set up (e.g. " When the second hand of the watch reaches 25, raise your hand ", or " When I count as far as 12, raise your hand "), the patient proved incapable of making the reaction ; the best the patient could do was to declare " Now it's reached 25 ! " or " That's 12 now " but would make no movement. It is characteristic too that this fact is explained not by the break-down of memory (after the unsuccessful attempt the patient when questioned was easily able to repro-

duce the verbal instruction) but by heightened external inhibition, as a result of which the activity which had started (following the hand of the watch or listening to a series of numbers) inductively inhibited the influence of the instruction and produced a break-down of its regulating function.

A characteristic feature of these highly peculiar functional disorders is the fact that the phenomena here observed do not amount merely to the break-down of the regulating function of *another person's speech* (or more accurately, the systems of connections set up by it). Experiments were carried out in which we asked the patient to confirm by his own speech the effect of the instruction, making him declare the significance of the stimulus e.g. by saying every time the red lamp flashed : " I am to press ! " and when the blue lamp flashed: " I am not to press ! "—a method worked out with us by Khomskaya, the influence of which in ontogenesis has been described elsewhere (Luria, 1956, 1957b). These experiments showed that even the patient's own speech, easily passing over to an inert stereotype, and losing the required connection with the signal, in fact also ceases to display its regulating effect. In these cases the patient either begins inertly to alternate the responses " I am to press ! ", " I am not to press ! ", or (if his speech reactions were sufficiently strong) correctly reproduces the required responses, but ceases to make the movements corresponding to them, replacing them by inert stereotypes.

The break-down in the regulating function of speech proves characteristic of the whole behaviour of such patients ; it deprives their activity of the required purposiveness and leaves an imprint on the whole character of their broken-down intellectual processes.

The close study of this form of speech disorder, which is empirically well known to clinical workers, but which has not received the attention it merits, is still in its infancy. But there can be no doubt that systematic research into the method of formation of the regulating effect of speech in ontogenesis, how it is brought about in normal behaviour and how it disintegrates in pathological conditions of the brain, will reveal a whole series of facts of considerable interest both for psychology and for that branch of science which deals with the pragmatic forms of speech activity.

We have thrown light here on only a few problems which are revealed to the psychologist when he uses the observation of pathological states of cerebral activity as a method permitting the discovery of some mechanisms of the speech processes which are internal and not easily approached by pathological investigation.

It would be a mistake—though unfortunately a common one—to think that pathological states of the brain return speech to stages it has once passed through and allow one to follow out the history of its formation in reverse. Pathological changes in cerebral activity break down one or another physiological condition, indispensable for the normal existence of speech processes ; therefore in fact they never reproduce any of the earlier stages of speech development. But " breaking down and simplifying what is fused and indivisible in the physiological norm ", they permit the use of this method as an important means of analysing the psychological construction of speech and the actual forms in which language is used.

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