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Neuropsychology as a Science

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A new branch of psychology has recently developed, - it is Neuropsychology.

This branch is of a great importance both for the applied problems of Neurological Medicine and for General Psychology. I happened to be a wittness, as well as a direct participant of the formation of this branch; and this is why I have chosen for this Evening lecture the topic of "Neuropsychology as a science".

1.

Neuropsychology has emerged as a result of the practical demands of modern Neurology and Neurosurgery.

I still remember the time - some forty years ago - when brain tumors and massive brain haemorhages were regarded as incurable and when the diagnosis of a brain tumor - no matter whether malignant or benign - was equal to a death sentence.

During the last few decades the situation has markedly changed. Brain tumors, as well as intracranial haemorrhages, have become objects of surgical treatment; new methods of preventing bleeding and brain swelling have made it possible to remove pathological foci from the brain tissue and to preserve the life of the patients for a long time. This is why the basic problem of early and precise diagnostics of the location of brain injuries, as well as the problem of creating a scientific basis for the recovery of patients after brain ~~injuries~~ lesions - have become now highly important.

We shall try to show, what scientific psychology can do to solve these problems, and first of all - how the psychological methods can ensure early and reliable local diagnostics of a brain injury. The solution of this problem is the first

practical task of Neuropsychology.

Precise diagnostics of the site of a tumor or haemorrhage is by no means an easy task. It is well known that the clinical methods of topical diagnostics of lesions are very limited.

After a century of experience the neurologists have developed a battery of neurological tests which prove to be relisble and valid for local diagnostics of some brain injuries; such symptoms as a loss of sensitivity, constrained movements, a change in the muscle tone and reflexes, and partial disturbances of the visual fields, - are of a great significance for precise diagnostics of the location of brain injuries.

And yet these symptoms are insufficient. As is known, at least three quarters of the entire area of the brain hemispheres have nothing to do with sensitivity or motility, with the muscle tone or reflexes; the predominant part of the human cortex may be considered as an apparatus which is responsible for the higher behavioral processes, elaboration and storage of information, programming, as well as control of human actions. It is evident that lesions of these zones do not result in disturbances of simple sensation, motion or reflexes, and that a thorough analysis of the complex changes in behaviour must be used for diagnosing lesions of these parts of the brain.

Now we come to the basic problem. It is well known that such behavioural processes as elaboration and storage of information or control of actions are of a highly complex nature and may suffer as a result of lesions of diverse, wide zones of the brain. Does it mean that a careful study of behavioural changes taking place in local brain lesions cannot be used for precise topical diagnostics of the location of lesions? The modern psychological approach to the structure of psychological

processes, as well as modern knowledge of the basic functional organization of the brain may be of a considerable help in our attempts to find a scientific answer to the afore mentioned question.

Let us examine in brief both problems. The primitive concept of psychological functions as elementary innate faculties based on separate circumscribed centres of the brain cortex - which existed in psychology during centuries - has now been fully discarded. After a series of important discoveries made by outstanding scholars it became clear that the behavioural processes are to be considered as complex self-regulating systems which begin with a definite goal, are based on a plan or program and are realized in a series of operations leading to an ultimate effect; it became also clear that the result of every action is signalized in the brain, and if the matching of the result with the initial plan shows that the action ended in success - the behavioural activity stops; if there is no such concordance, it continues. This self-regulating structure of every psychological process is differently formulated by various scholars; thus it is generally known as the process of T-O-T-E of Pribram, Miller and Galanter, as the mechanism of the "Acceptor of Action" of Anokhin, or the process of matching of "Ist-Wert" and "Soll-Wert" of N.Bernstein. This scheme is equally applicable to such elementary systems as breathing or walking and to such complicated behavioural systems as writing, reading, problem solving and decision making; the only difference is that complicated psychological systems are social or historically by origin, indirect, tool or symbol using by structure and conscious or voluntary by their mode of functioning.

Now we come to the basic question: what is the cortical

organization of these complex and self-regulating functional systems?

It is obvious that they cannot be "localized" in circumscribed groups of nerve cells and that no isolated "centers" for complex functional systems can exist. But from modern Neurology it is equally obvious that the complex behavioural processes are by no means functions of equipotential parts of the brain tissue and that different parts of the brain do not play the same role in their organization.

All we know from modern Neurology leads to the conclusion that complex behavioural processes result from the co-ordinated work of the dynamic systems of different parts of the brain, and that each part of the brain plays its own, highly specific role in the organization of psychological processes.

This is why complex behavioural processes may suffer as a result of different lesions of the brain; but lesions of different parts of the brain bring about disturbances of specific psychophysiological factors and are associated with very different types of disturbances of the same functional system.

This is why a thorough neuropsychological analysis of the behavioural changes in cases of differently located lesions of the brain should be applied for topical diagnostics of the local brain lesion.

This turns Neuropsychology into a valuable method of early and precise local diagnostics of brain lesions.

2.

Let us now summarize the basic principles underlying the functional organization of the Human Brain; a clear under-

standing of these principles is of great significance for Neuropsychology.

Modern Neurological Science can single out at least three basic blocks, which constitute the basic functional parts of the brain; these blocks participate in every behavioural process, each of them making its own contribution to the construction of psychological processes. This is why a disturbance of any block results in a disorganization of complex forms of human behaviour, but the type of this disorganization is different in lesions of different blocks.

The first block may be designated as a block of the energy and tone of cortical processes. After the brillant investigations of Magoun and Moruzzi, Jasper and Lindsley it is evident that this functional unit includes the apparatuses of the lower and higher brain stem and the reticular formation. These parts of the brain stem are in close two - way relations with the Cortex, especially with the meso - basal parts of the frontal lobes; they ensure a stable optimal tone of the cortex, which is one of the most important conditions for the normal organization of psychological processes, selective organization of the input and storage of information, stable preservation of the plans and programs of behaviour, and precise evaluation of the outcome of actions.

If the first block is injured, and a tumor or haemorrhage disturbes the higher parts of the brain stem, the walls of the third ventricle or the limbic parts of the brain, - the whole cortex comes into a pathological state: the tone of the cortex, the stability of the normal neurodynamic processes become disturbed; a marked deterioration of wakefulness and a disorganization of memory traces are observed, and the selectiv-

ty of the psychological processes suffers.

You probably know the general law of neurodynamics described by Pavlov as "the law of force". In a normal cortex strong or significant stimuli prove to predominate and evoke strong reactions, while feeble or insignificant stimuli evoke unstable traces and may be easily suppressed. This provides a selective concentration of the excitatory processes and constitutes one of the most important conditions for the highly selective organization of all mental processes.

The situation changes when the tone of the cortex declines. I.P. Pavlov described the " inhibitory states" of the weak cortex as follows: now strong or significant stimuli evoke the same responses as weak or insignifixant ones; a concentration of the excitatory processes in dominant foci becomes impossible, and when the inhibitory state increases, the paradoxical state of the cortical manifests itself: weak or insignificant stimuli begin to evoke even stronger reactions than strong and significant ones.

You can imagine what a disorganization of the normal flow of psychological processes is associated with such states; remember how diffuse and disorganized become our thoughts in a drowsy state, and how strange are our associations in the states of fatigue and dream... It is obvious that lesions of the higher parts of the brain stem, tumors of the third ventricle or of parts of the limbic system inevitably result in marked changes of behaviour: the mental processes become instable and exhaustible; the memory traces turn to be weak and are easily inhibited by any interference; the flow of associations loses its normal selectivity and the control of behaviour becomes deranged. A year age I described jointly with my friend Dr. Macdonald Critekly some behavioural disturbances

resulting from tumors of the mesial parts of the frontal lobe; since that time new data have been accumulated on disturbances in the stability of behavioural processes caused by lesions of the deep parts of the brain.

The second block of the brain has been much better studied and its role in the functional organization of behaviour has been ascertained to a considerably greater degree. It includes tne posterior parts of the cortex and plays a decisive role in the input, coding and storage of information. Its functional organization greatly differs from that of the first block: while the nervous apparatus of the first block is to a considerable degree unspecific and is responsible for a gradual change of wakefulness, - the neuronal systems of the second block are modally specific; we can easily distinguish separate parts of the cortex which play the roles of optic, acoustic, cutaneous or kinesthetic analyzers. In contradistinction to the apparatus of the first block, - every part of the second block has a very precise hierarchical organization: its base is a circumscribed primary (or extrinsic) cortical zone - a zone of the input of visual, acoustic or sensory information; these zones are organized by corresponding secondary (or intrinsic) zones which play a decisive role in the further organization and coding of information; the hierarchical organization is terminated in tertiary zones which can be designated as zones where different modally specific parts of the cortex overlap one another; they serve as special devices of simultaneous synthesis of separate data and are necessary for the organization of simultaneous (quasi-spatial) schemes of behaviour.

The principles of the functional organization of these zones are well known, and the latest research into the function

of single neurons with the highest level of specificity of their work, described by Hubell and Wiesel, Jung and others, open up new vistas for the analysis of their internal mechanisms.

It is clear that injuries of different parts of this second block of the brain result in behavioural disturbances which greatly differ from those caused by lesions of the first block.

Lesions of the primary zones of this block result in very specific visual, acoustic or sensory defects, and yet fo not bring about marked behavioural changes. Lesions of the secondary zones are associated with more complicated disturbances which, as a rule, are restricted to specific modalities. Such well known facts as optico-gnostic or acoustico-gnostic defects can serve as exemples of such functional disorders. It should be emphasized that lesions of the secondary zones of the occipital or temporal area of the cortex are not only inevitably associated with very specific processes of coding information of a certain modality, but lead to a disorganization of all complicated behavioural processes which include the affected link and which cannot remain normal when the coding of corresponding information is disturbed, while all behavioural processes not including the damaged link, remain undisturbed. Later on, we shall see the great importance of this fact for Neuropsychological diagnostics of local brain injuries.

Perhaps of special significance for neuropsychology are the consequences of lesions of the most complex - tertiary zones of this block.

The Neurologist knows very well that lesions of the "zones of overlapping" - and first of all of the infro-parietal (or temporo-parieto-occipital) parts of the cortex not only results in a deterioration of such processes as visual orientation in space, but plays an essential role in the dis-

organization of complex symbolic processes. Such lesions inevitably result in a disturbance of the "synthesis of separate traces in coherent wholes", and one of the most important findings of Neuropsychology is that complex logico-grammatical, semantic and numerical operations, which have a quasi-spatial ground, become impossible after lesions of the parieto-occipital parts of tne left hemisphere. We have analyzed these disturbances in special books and shall not dwell on them here any longer.

We have spent much time on studying the role of the third block in the organization of behavioural processes. This block includes the anterior parts of the brain and is intimately involved in the organization of intentions and plans, in the programming regulation and control of behaviour. A group of outstanding scholars - from Bianchi to K.Pribram and Konorski in the field of animal studies, Bekhterev and Kleist and Denny Braun in the field of Clinical observations - have made important contributions to our knowledge of the functions of the frontal lobes, and I can only summarize here our findings.

It is well known that the Frontal Lobes - this latest and most complex part of the Human hemispherers - do not perform any sensory or motor functions and that severe lesions of the Frontal Lobes are not associated with defects in sensations, movements, gnostic and practical processes, or speech. Nevertheless the Human Frontal Lobes by no means can be considered as "mute zones" of the cortex, and a series of latest findings made it clear how important their participation in every complex behavioural process is.

The frontal Lobes of the Human brain, and first of all their mesial and basal parts, have very intimate ascending and

descending connections with the brain stem and its reticular formation, and this turns the Frontal Lobes into an important device for regulating the active states of human behaviour.

Only a few years ago Grey Walter showed that each active expectancy evokes special slow waves in the Frontal cortex, and these "expectancy waves" disappear when the subject's attention is exhausted. Simultaneously M.Livanov from Moscow showed that each intellectual strain results in an emergence of a complex of synchronously excited points in the frontal cortex and that these synchronously working foci disappear when the subject is in a passive state or after application of tranquilizers.

These data made it highly probable that the Human Frontal Lobes play a decisive role in the process of activation.

This assumption was confirmed by observations carried out by my friend Dr. E.D.Homskaya and her co-workers in our laboratory. A series of experiments proved that a verbal instruction which adds a special signalling function to some stimulus ("pay attention", "count the stimuli", "press the key when the stimulus appears") causes in a normal person marked ~~vegetative~~ vascular and electrophysiological changes which may be regarded as symptoms of an orienting reflex (constriction of vessels, depression of the alpha rhythm, change in the frequencies of the EEG and in the asymmetry of ascending and descending fronts of the alpha waves, intensification of evoked potentials). All these changes can be observed also in patients with lesions of the posterior parts of the brain; but they disappear in patients with severe lesions of the Frontal Lobes, and especially of their mesial parts.

This proves that the Frontal Lobes play an important role in the regulation of the active states of the brain, and that

lesions of the Frontal Lobes result in the inability to preserve vigilance, which is basically important for all stable decisions, preservation of plans and active regulation of behavior.

This role of the Frontal Lobes in the process of activation explains a number of behavioural changes observed in patients with severe lesions of the Frontal Lobes.

The psychiatrists know perfectly well that patients with tumors or wounds of the Frontal Lobes become inactive, lose the future - oriented behaviour and are unable to evaluate the effects of their action. They lose the ability to create intention and to follow the programms which are given by means of verbal instructions; although they retain the instructions, they are unable to follow them, and their meaningful, selective behavior becomes easily replaced by impulsive "field-linked" actions or passive stereotypes.

If the patient is asked to produce a simple reaction, imitating the movement of the experiment~~e~~r, he does it successfully; but if the instruction requires a re-coding of the given stimulus and the movement must follow some intermediate program (for example, when the following instruction in given: "When I lift my finger - you will show me your fist; and when I lift my fist - you will show me finger") - the required action is very soon replaced by primitive imitative reactions. The same is observed if the patient is asked to ~~give~~ produce a reaction of choice by lifting his right hand after a single knock, and his left hand after a double knock. It is sufficient to repeat this action two or three times and then to change the sequence of signals, - and the patient ceases to produce an adequate

choice reaction and replaces it by senseless stereotyped sequences of movements (R-L-R-L-R-L), irrespective of the signals.

Such a loss of the selective, programmed forms of behaviour can be seen in more complex experiments where dominant intentions are replaced by unselectively evoked associations or inert stereotypes.

If a patient with a severe lesion of the Frontal Lobe cannot follow ready-made programs given in the instruction, it is evident that he becomes totally unable to create his own plans, to select useful information and to construct the strategy of complex behaviour.

We can illustrate this by two experiments,

It is well known that if a normal person is given the instruction to touch, with his eyes closed, a set of checkers, one of which has the form of "H" and the second - the form of "E" and then to decide which of the two letters has been presented to him, the subject begins with extended trials, but very rapidly replaces these trials by an abbreviated process, singling out the useful information and touching only the informative checkers which form the difference of the two letters. The matter is quite different in the case of Frontal Lobe patients. No searching movements and no abbreviation of the process take place; neither are observed attempts to single out useful information; the patient continues to touch all checkers, but is unable to receive the proper information and to make the required decision.

The same can be seen even in a more impressive experiment.

It is well known that the evaluation of complex visual information requires a certain strategy of perception, and that the subject's eye movements reflect such a strategy. This can

be very easily demonstrated by recording the eye movements of a normal person when he observes simple and complicated pictures: for this purpose a mirror is fastened to the sclera and the beam of light reflected during this observation is recorded (a method proposed by A.L.Yarbuss). The records thus obtained show that a normal person singles out the most informative points of the picture, but when a different instruction is given, - the strategy of the eye movement changes entirely.

No such process takes place in patients with lesions of the frontal lobes: searching, meaningful movements are in this case replaced by senseless, chaotic or inert (stereotyped) eye movements showing that the strategy of selective, searching actions proves impossible.

I shall spare your time and shall not dwell on the analysis of the dissolution of the problem solving behavior in these patients; it is described in one of my latest books written with Dr. L.S.Tsvetkova, where full information on this subject may be obtained.

Here I shall stop our analysis of the basic functional blocks of the Human Brain and of their role in the organization of behavioural processes.

It is obvious that each block takes part in the organization of complex behavioural processes, playing its own role in this respect. That is why a thorough neuropsychological study of the type of behavioural changes caused by local Brain lesions may be of a great value for local diagnostics of Brain injuries.

3.

We have summarized our knowledge about the basic blocks of the human brain. Now we can return to our initial question: may psychology be of any help in the local diagnostics of brain injuries?

Now it is clear that complex psychological processes are not localized in definite circumscribed cortical areas and that every form of complex behaviour results from the joint work of functional systems of different zones of the brain, each of them adding its own component to the physiological bases of the behavioural processes.

This is of decisive significance for the evaluation of the behavioural symptoms of every local brain injury. It means that disturbances of complex behavioural processes may result from differently located brain lesions; each time however the pathological focus eliminates a certain specific factor participating in the functional system, and the structure of the behavioural disturbance proves to be different.

Let us illustrate it by a single example which will show the importance of a sophisticated psychological analysis behavioural processes disturbed in the case of differently localized brain injuries.

For didactic purposes we shall choose the example of disturbances of writing caused by different local lesions of the brain. This example will make it possible to establish the type of Neuropsychological analysis of a very complicated disturbance and serve as model of psychological evaluation of a local brain injury.

The idea that disturbances of writing result from very circumscribed lesions of the middle parts of the premotor zone of the left hemisphere - the so-called "Exher's centre" was refuted more than half a century ago. During the first decades of the present century it became clear that writing is by no means a complex system of hand movements, that its structure is much more complex, and that actually writing

defects may be observed in cases of cortical lesions of a very broad area of the left hemisphere. But neuropsychological observations showed that the character of the writing disturbances greatly varies in lesions of different zones of the human cortex

Let us start with a psychological analysis of the process of writing, and try to explain how this process suffers in different lesions of the brain.

In order to write down a word, we have to listen to a continuous flow of speech sounds and to single out separate, discrete phonemes which must be coded by letters. This is a complex process, and a good ear is far from being sufficient for such analysis. Every language has its own phonemic system; it means that every language uses its own acoustic cues which play a decisive role in the discrimination of one meaning from another. Sometimes these cues are very delicate, but to a person who has grown up in the culture of given language they are easily distinguishable; to an Englishman for example the words "vine" and "wine", "special" and "spatial" sound very differently and he may hardly make a mistake in their discrimination; so are the sounds "b" and "p" both in the English and in the Russian languages; the words "bull" and "pull", "bark" and "park" are very different and hardly have some common features, although their acoustic difference is very slight.

The situation changes if we turn to phonemic systems which differ from those in our native language. The Russian cue of "hardness" and "softness" is alien to the English or French language, and this is why the following three words which are absolutely different for a Russian - жар - ardour, пыль = dust, and пил he drunk - are hardly distinguishable to an English - or French speaking person. The same is

characteristic of the Chinese language, where the height of the pitch is a decisive cue, and where "ma↓" means "to buy" and "ma↑" means "to sell", or of one of the Caucasian languages where "antlico" means "six" and "antʃlico" - means "seven". Finally, I shall only mention that in the Vietnameese language the phoneme "tü", is pronounced with different pitches and accordingly has at least six meanings!

But the differentiation of phonemes is effected with the participation of the cortical parts of the "acoustic analyser" - especially of the secondary zones of the left temporal lobe, which have intimate connections with other parts of the "speech area"; this is why lesions of this zone result in a disturbances of the discrimination of close (or correlative) phonemes, and patients with wounds of this region become unable to discriminate such sounds as "b" and "p", "t" and "d" even in their own language, regarding them as insignificant variations of the same phoneme. As a result of our observations on many hundreds of patients with local brain wounds and tumors, this discrimination of phonemes turned into one of the most reliable tests of lesions of the left temporal lobe.

This basic defect produces some secondary results; one of them is a severe disturbance of writing in patients with lesions of the left temporal zone. Of definite importance is the fact that such disturbances are of a very distinct type: patients with lesions of the left temporal lobe confuse in their writing the "correlative phonemes", they, forcexample, CAN write "tome" instead of "dome" or "pull" instead of "bull"; they are hardly able to single out separate phonemes from among complex groups of consonants, and their writing becomes highly disturbed.

It is very interesting to note that severe disturbances

of writing in patients with lesions of the acoustic regions of the dominant hemisphere, which is one of the basic symptoms of such lesions in Europeans, are not observed in the Chinese because their writing is ideographic and is not based on the discrimination of different phonemes!

An acoustic analysis of phonemes is the first step of the process of writing but by no means the only one.

To improve the analysis of the phonemes, one must sometimes apply additional aids, such as sound articulation and motor analysis of the structure of the word. "How do you spell your name?" one asks when the phonemic structure of the name remains uncertain: "B-r-a-m-b-l-e?..." But when we add an articulatory analysis of the word - its structure becomes clear, and we are able to write it down.

To verify the role of articulation in writing, I asked one of my co-workers to carry out a special observation on school cheldren in class conditions. If you enter the class room of first or second grade pupils when they study writing - you often hear a noise: the pupils try to pronounce the words they write, and thus the class room is full of a buzz. It this useful or distractive? The teachers can hardly answer this question.

In order to answer it, I asked one of my co-workers to compare the process of writing, when it is accompanied by such repetition of the words aloud with the same process conducted in quite different conditions, when the children were asked to write holding their mouths open or squeezing their tongues between their teeth. In the last case the number of their writing mistakes increased six fold!

This means that at the first stages of learning oral articulation of the words is of considerable help for evaluating

the sounds and for mastering the process of writing and that only at the latest subsequent stages this component becomes less significant.

But precise articulation necessitates the participation of different cortical zones, - and first of all of the post-central (kinethetic) parts of the cortex of the left hemisphere. This is why in lesions of these cortical parts we observe disturbances of precise articulation, in particular, a confusion of similar (or correlative) articulemes (such as "b" and "m", or "d", "e" and "n"), as well as new difficulties in writing, - this time in the form of confusing letters which are differently articulated. In such cases the Russian patient may write "ston" (groan) instead of "stol" (table), "khanat" or "khadat" (meaningless) instead of "khalat" (dressing-gown). - To an experienced Neuropsychologist such mistakes give ground to suspect a lesion of the central parts of the dominant hemisphere as the cause of the writing disturbances.

The process of writing begins with the evaluation of phonemes, but it must make several steps further.

The next step of this process is the re-coding the acoustic units of speech - the phonemes - in by the visual units of the writing process, i.e. letters or graphemes. This requires the participation of different parts of the brain - especially of the visual (occipithal) and spatial (parieto-occipital) zones of the cortex in close collaboration with the acoustic (temporal) zones. This is why the process of writing proves to be severely disturbed in lesions of the left temporo-occipital and parieto-occipital parts'; but the type of the disturbances in these cases markedly differs from what we have described earlier.

Patients of this group do not experience any difficulties in analysing the acoustic constitution of the word; nor do they confuse their phonemic elements. But they manifest marked difficulties when they begin to re-code the phonemes in letters or graphemes: the relationship between the letters and sounds is often lost, and the patient begins to look without success for the letter he needs, saying: "Oh, which is the real letter for "n"? - this one, or that one?", or tries to ascertain the spatial relationships between the elements of the letters, experiencing difficulties in distinguishing the required structure of the letter from the mirror one, and being unable to combine separate parts of the letter into a coherent whole. All these difficulties are obvious symptoms of lesions of the visual and spatial zones of the cortex; they can be easily distinguished from the symptoms of lesions of tne acoustic or kinestetic zones.

We have described the first two thirds of the process of writing; now let us turn to the last part of this process.

To write down a word is not the same as to write down a letter; the word consists of a sequence of sounds and letters. This is why the subject must preserve the sequential order of the elements and analyse its serial organization.

Here we come to a new, and most essential point in the organization of the Higher Cortical Processes.

It was K.S.Lashley who thirty years ago found that spatial and sequential analyses are incompatible processes, and that different zones of the brain are required for their organization. In the course of special observations carried out during several decades we found that while spatial analysis is ensured by the parieto-occipital parts of the cortex, serial or sequential analysis requires the participation of the anterior parts

of the hemisphere, whether temporal (acoustic) or premotor. This is why disturbances of the fronto-temporal and lower parts of the premotor zones of the left hemisphere, result not only in disturbances of the prosodic (rhythmical) organization of movements, but also in severe disturbances of the serial organization of the speech and writing processes. Patients with such lesions display grave difficulties in preserving the sequence of letters in the press of writing; they change the position transpose of separate letters in the word, sometimes are unable to proceed from one letter to another and often replace the required serial order by an inert stereotype. If the lesion is located in the deep parts of the brain and violates the normal relations between the cortex and the basal ganglia, new symptoms arise - this time in the form of forced repetitions of some fragments of the letter; the patient becomes unable to write, although his acoustic analysis of the verbal sounds or his spatial analysis of the components of the graphemes remain intact.

May I only mention the last - but most important defect in writing?

We don't write merely letters or words; we express in writing our intentions and thoughts, and when the apparatuses of the third block of the brain is damaged, which takes place in cases of severe lesions of the frontal lobes, the intentions and plans become disturbed; the patient is unable to express his intentions and thoughts both in verbal and written form. I cannot forget a letter written by a woman with a severe lesion of the left frontal lobe to the famous Russian Neurosurgeon Burdenko. "Dear Professor," she wrote, "I want to tell you that I want to tell you that I want to tell you..." and far pages of the letter didn't go a step furter!..

We have completed our psychological analysis of the process of writing and of the symptoms of its disturbances in cases of different local lesions of the brain. This was only a single example, but with its help we have learned important facts concerning the style of neuropsychological analysis of this model and of its disturbances in different local brain lesions.

We have established that a behavioural process may suffer as a result of lesions of different parts of the brain, but in cases of different localization of the injury the type of the disturbance is different ~~not similar~~. This is why the work of a Neuropsycnologists who wants to use his method for local diagnostics of a brain lesion does not consist in a more statement that the given function is disturbed, but rather in a qualifying the type of the disturbance, in finding the primary defect which underlies this disturbance and in describing all the secondary or systemic disorders following this primary defect. We have chosen disturbances of writing as a model for such analysis; but we could likewise use as an example the Neuropsychological analysis of perception or movement, of memorization or concept formation, of accomplishment of a planned action or problem solving.

During the last three decades we elaborately analysed the differences between the disturbances of all these processes in local brain lesions and showed that a detailed description of the kind of a given disturbance can be used for local diagnostics of a brain injury.

Precisely this constitute the basic method of Neuropsychology.

4.

We have seen how Neuropsychology can be used as a valuable

method of local diagnostics of a brain injury. But Neuropsychology is not only an applied branch of psychology it is a self-sustained science as well; this means that important theoretical inference can be drawn from Neuropsychological investigations.

When we say that each cortical zone participates in the organization of behavioural processes in its own way, we have in mind that new ways for analysing special factors included in the behavioural processes may be discovered, and that a truly new approach to the factor analysis of complex psychological processes must be elaborated.

You all remember the efforts made in psychology to discover separate constituants of the psychological processes and to learn more about the inner structure of the complex behavioural capacities. Complicated methods of intercorrelation of the results of batteries of different tests in vast populations were used, and it is sufficient to remember the names of such brilliant scholars as Spearman and Thurstone, not mentioning more recent names, to appreciate all the efforts made in the field of solving this problem.

Neuropsychology opens a new kind of psychological factor analysis, it is a factor analysis within the limits of one person.

If a local brain lesion results in a disturbance of one of the factors entering a complex behavioural process - the basic tone of the cortical processes, the acoustic or kinesthetic analysis, the spatial organization of the input or sequential organization of the psychological processes - clear-cut secondary consequences are observed: all the complex behavioural processes which include the given factor become

disturbed, while all the behavioural processes in which this factor is absent remain intact. We know from our clinical observations that in cases when lesions of the left temporal lobe result in defects of the acoustic analysis of speech sounds, the perception of speech, repetition of verbal sounds, naming of objects, as well as writing become severely violated, but the orientation in space or simple computation remain uneffected. On the contrary, cases of lesions of the left parieto-occipital cortex, which destroy the simultaneous or spatial organization of information are closely associated with disturbances of complex practical or symbolic defects - and do not result in any dissolution of fluent speech or prosodic melodies.

This opens up new vistas for the analysis of factors underlying different behavioural processes. We can easily observe how different psychological functions are correlated in one person, and which groups of functions have common factors.

Three main tasks become possible due to the use of this method of analysis: we can detect basic differences in quasi-similar processes; we can discover common factors in processes which at first glance seem different; and we are able to evaluate different inner structures of the same behavioural processes at different stages of their functional development.

Let us examine these three problems separately.

There exist psychological processes which seem to be closely related to one another, if not identical, as regards their components, although it is not so easy to prove this relationship. An example of such a process is the acoustic perception of verbal and musical sounds.

Neuropsychological investigations produce unexpected results:

as shown by several authors, lesions of the left temporal lobe result in marked disturbances of the discrimination of phonemes, while musical hearing remains undisturbed. I had the opportunity to observe during three years an outstanding Russian composer who had endured a haemorrhage in the left temporal lobe, suffered from severe sensory aphasia and was unable to single out verbal sounds and to understand oral speech, yet during these years he created wonderful symphonies. Doesn't it prove that absolutely different factors are involved in these two processes which seem to be so closely related at first glance?

There exist psychological problems of an opposite type. Some behavioural processes seem to be so different that one can hardly find something common in them. Indeed what can there be in common between orientation in space, computation and understanding of complex logico-grammatical structures? An analysis of this problem with the help of Neuropsychology may lead to a very unexpected conclusion. It is well known that lesions of the inferior part of the left parietal zone inevitably result in disturbances of the orientation in space, which are associated with severe defects in computation, and in the inability to understand complex logico-grammatical constructions. Doesn't it mean that there exist common factors in these quasi different behavioural processes?

A close analysis of these data reveals the nature of such common factors. In order to substract 7 from 31, one must first perform the operation 30-7 = 23, and then add the remaining "1". This is easy for a normal subject; but a patient with a lesion of the inferior part of the left parietal lobe is unable to cope with this task; he is at a loss what to do - whether to place the remaining "1" to the left or to the right of the

result obtained, in other words, to add or to substract it. It is clear that other more complex arythmetical operations remain are likewise fully inaccessible to him as a result of his defects.

The same can be said about the understanding of complicated, relational logico-grammatical forms.

To understand the difference between such constructions as "father's brother" and "brother's father", "The cross is under the triangle" or "the triangle is under the cross", "summer comes after spring" or "spring comes after summer" as well as such relational constructions as "Jenny is darker than Kate, but fairer than Ann", - one has to place the elements of this construction in an "inner psychological space" and to grasp the quasi spatial relations between the alternatives mentioned. This is why lesions of the inferior parts of the left parietal zones, eliminating the factor of simultaneous spatial synthesis result in a disturbance of these complicated forms of verbal behaviour.

It is clear that the discovery of differences between both very similar and common factors in very different behavioural processes is of great importance; and we may suppose that the structure of future psychological science will substantionally differ from its present-day structure, and that Neuropsychology will play a decisive role in this development.

Let us now pass to the last question which is of high psychological interest.

It is well known that after a certain period of training the behavioural processes can be automatized and that higher organized skills can be developed.

Does it mean that in the course of this process the whole structure of the psychological function is changed and that its cortical organization assumes new forms? One can

We have done our best to characterize the basic feature of Neuropsychology as a Science. We have tried to show its birth associated with the successes of modern Neurosurgery, its practical application and its significances for the psychological theory.

We are sure that Neuropsychology - this youngest branch of psychological sciences - is now standing on terra firma and that it will occupy a prominent place in the solution of the most complicated problems of Human Behaviour.

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