A.R.Luria

Neuropsychology as a Science

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During the last period a new branch of psychology has developed, - and that is Neuropsychology.

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

1.

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

I still remember a time - some fourty years ago - when brain tumors and massive brain halmorrhages were supposed to be incurable and when the diagnosis of a brin tumor - malignant or benign - was equal to a death sentence.

During the last few decades the situation has changed. Brain tumors as well as intracranial halmorrhages have become an object of surgical treatment; new methods of prevention of bleading and brain swelling made it possible to remove

pathological foci from the brain tissue and to preserve the life of the patients for a long time. That is why the basic problem of an early and precise diagnostics of the location of the brain injury, as well as the problem of the scientific bases of the rehabilitation of patients after brain injury - became new most important.

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

A precise diagnostics of the site of a tumor or haemorrhage is not at all an easy task. It is well known that the clinical methods of topical diagnostics of a lesion are very limited.

After a century of experience Neurologists have developed a battery of Neurological tests which are valid and reliable for a local diagnostics of some brain injuries; such symptoms

as loss of sensitivity, restriction of movements alteration of the tone of the muscles and of reflexes, partial disturbances of visual fields, - are of a high value for a precise diagnostics of the location of brain injuries.

But these symptoms have a limited value. It is well known that at least three quarters of the territory of the brain hemispheres have nothing to do with sensitivity or motility, ~~i~~ muscle tone or reflexes; the predominant part of Human Cortex can be considered as an apparatus of higher behavioral processes, of elaboration and storage of the information, of programming, and control of human actions. It is evident that lesions of these zones don't result in disturbances of simple sensation, movement and reflexes, and that a careful analysis of complex changes in behavior has to be used for the diagnostics of lesions of these complex parts of the brain.

Now we come to the basic problem: it is well known that such behavioral processes as elaboration and storage of

information or control of action are processes of a high complexity, and that they can suffer in lesions of very different, widespreaded zones of the brain. Does it mean that a careful study of behavioral changes in local brain lesions cannot be used for a precise topical diagnostics of the location of the lesion? Modern psychological approach to the structure of psychological processes, as well as modern knowledge of the basic functional organization of the brain can be of a considerable help in our attempts to find a scientific answer to this question.

Let us examine both problems very shortly.

Primitive concept of psychological functions as simple inborn faculties based on separate circumscribed centra of the brain cortex - which remained in psychology during centuries - is now totally abandoned. After a series of important discoveries of a series of outstanding scholars it became clear that behavioral processes are to be considered as complicated <u>self regulating systems</u> which start with a

basic goal, are based on a plan or program and are realized in a series of operations, leading to an ultimate effect; it became clear that the effect of every action is signalized in the brain, and if the matching of the result of the action with the initial plan shows the action succeeded - the behavioral activity stops; it such concordance is absent - the action continues. Such self-regulating structure of every psychological process is differently formulated by different scholars and it is well known as the process of T-O-T-E of Pribram, Miller and Galanter, as the mechanism of the "Acceptor of Action" of Anoktin or the process of matching of "Ist-Wert" and "Soll-Wert" of N.Bernstein. This scheme is equally acceptable for such elementary systems as breathing or walking as for such complicated behavioral systems as writing or reading, problem solving and decision making; the only difference is that complicated psychological systems are social or historically 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 nervous cells and that no isolated "centra" for complex functional systems can exist. But we ~~knew~~ from the modern Neurology it is equally obvious that the complex behavioral processes are in no case functions of equipotential parts of the brain tissue and that different parts of the brain don't play the same role in their organization.

All we know from modern Neurology leads us to a conclusion that complex behavioral processes are results of a co-ordinated work of dynamic systems of different parts of the brain, and ~~th~~ that every part of the brain plays its own, highly specific role in the organization of psychological processes.

That is why complex behavioral processes can suffer in cases of different lesions of the brain; but lesions of different parts of the brain result in disturbance of very different,

specific factors and are associated with very different type of disturbance of the same functional system.

That is why careful neuropsychological analysis of behavioral changes in cases of differently located lesions of the brain can be applied for a topical diagnostics of the local brain lesion.

And that makes Neuropsychology a valuable method an early and precise local diagnostics of the lesions of the brain.

2.

Let us now summarize the basic principles of the functional organization of the Human Brain; a clear understanding of these principles is of a basic signiticance for Neuropsychology.

Modern Neurological Science can single out at least three basic blocks, which are the basic functional parts of the brain; all these blocks participate in every behavioral process, each of them making its own contribution to the construction of psychological processes. That is why a disturbance of each block results in a disorganization of

complex forms of human behavior, but the type of this disorganisation is different in lesions of different blocks.

The first block can be designated as the block of energy and tone of cortical processes. After the brillant investigation 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 double - way relations with the Cortex, especially with the mesio - basal parts of the frontal lobes; they provide a stable optimal tone of the cortex which is one of the most important conditions for a normal organization of psychological processes, a selective organization of the input and storage of information, for a stable preservation of the plans and programs of behavior, for a 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 ventricles or the limbic parts of the brain, - the whole cortex comes in a pathological state: the tone of the

cortex, the stability of normal neurodynamic processes become disturbed, marked deterioration of wakefulness, disorganization of memory traces is seen, and the selectivity or the psychological processes suffers.

You may know the general low of neurodynamics described by Pavlov as "the low of force". In a normal cortex strong or significant stimuli become dominant and evoke strong reactions, while feable or unsignificant stimuli evoke unstable traces and can be easily suppressed. That provides a selective concentration of excitatory processes and that is one of the most important conditions for the highly selective organization of all mental processes.

The situation changes when the tone of the cortex is lowered, and Pavlov's observations described the "inhibitory states" of the weak cortex: now strong or significant stimuli evoke the same responces as the weak or unsignificant ones, a concentration of excitatory processes on dominant foci becomes impossible and when the inhibitory states increases, the paradoxical state of the cortical processes is

seen and weak or insignificant stimui begin to evoke even stronger reactions that strong and significant one.

You can imagine what a disorganization of a normal flow of psychological processes is associated with such states; remember how diffuse and disorganized became our thoughts in a drowsy state, and how strange are our association in situation of fatigue and dream... It is obvious that a lesion of the higher parts of the brain stem, tumors of the third ventricle or parts of the limbic system inevitably result in marked changes of behavior: mental processes become instable and exhaustable; memory traces turn to be weak and are easy inhibited by every interference; the flow of association loses its normal selectivity and the control of behavior suffers. A year ago I described jointly with my friend Dr. Macdonald Critchley some behavioral results of a tumor of the merial parts of the frontal lobe, and since that ~~publication~~ new data on the disturbance of stability of behavioral processes in lesions of the deep parts of the brain are collected.

The second block of the brain is much better studied and its role in the functional organization of behavior is much better known. It includes the posterior parts of the cortex and plays a decisive role in the input, coding and storage of information. Its functional organization is highly different from the first block: while the nervous apparatus of the first block are to a considerable degree unspecific and provide a gradual change of wakefulness, - the neuronal systems of the second block ~~have~~ are modality specific, and we can easily distinguish separate parts of the cortex which ~~have~~ play a role of optic, acoustic, of cutaneous or kinesthetic analyzers. In contradistinction to the apparatuses of the first block, - every part of the second block has a very precise hierarchical organization: it has as a base a circumscribed primary (or extrinsic) cortical zones - zones of the input of visual, acoustic or sensory information; these zones are organized by corresponding secondary (or intrinsic) zones which plays a decisive role in further organization and coding of infor-

mation; the hierarchical organization is completed in tertiary zones which can be designed as zones of overlapping of different modality specific parts of the cortex, which serve as special devices of simultaneous synthesis of separate data and which are necessary for the organization of simultaneous (quasi-spatial) schemes of behavior.

The principles of the functional organization of these zones are well known, and the latest findings of the function of single neurous with the highest specificity of their work, described by Hubel and Wiesel, Jung and others open new vistas in the analysis of their internal mechanisms.

It is clear that injuries to the different parts of this second block of the brain result in behavioral disturbances which are very different from these resulting from lesions of the first block. Lesions of primary zones of this block result in very specific visual, acoustic or sensory defects and don't yet bring marked behavioral changes. Lesions of the secondary zones are associated with more complicated dis-

turbances which as a rule are restricted to specific modalities. Such well known facts as optico-gnostic ~~a~~ defects or acoustico-gnostic can serve as exemples of such functional disorders. It has to be stressed that lesions of secondary zones of occipital or temporal zone of the cortex are inevitable associated not only with very specific processes of coding of information of a certain modality but has as a result a disorganization of all complicated behavioral processes which include the disturbed link and which cannot remain normal when the coding of corresponding information is disturbed, while all behavioral processes which don't include the damaged link remain undisturbed. We shall see further what a great importance has this fact for Neuropsychological diagnostics of local brain injuries.

Perhaps of ~~the~~ special importance for neuropsychology are the results of lesions of the most complex - tertiary zones of this block.

Neurologist know all right that lesions of the "zones

of overlapping" - and first of all of the infro-parietal (or temporo-parieto-occipital) parts of the cortex does not only result in a deterioration of such processes as visual orientation in space, but plays a decisive role in disorganization 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 ~~the disorganization of~~ that complex logico-grammatical, semantic and numerical operation, which have a quasi-spatial ground become impossible after lesions of parieto-occipital parts of the left hemispere. We have analyzed these disturbances in special books and shall not dwell on them further.

We have spent a considerable time studying the role of the third block in organization of behavioral processes. It includes the anterior parts of the brain and is intimately involved in organization of intentions and plans, in programming regulation and control of behavior. A group of outstanding scholars from Bianchi to K.Pribram and Konorski in animal studies,

Bekhterev and Kleist and Denny Braon in Clinical observations have made important contributions to our knowledge about the functions of the frontal lobes, and I can only summarize our findings.

It is well known that the Frontal Lobes - the latest and most complex part of the Human hemispherer have neither sensory or motor function, and that severe lesions of the Frontal Lobes are not associated with defects of sensations, movements, gnostic and practic processes or speech. Nevertheless Human Frontal Lobes in no case can be considered as "mute zones" of the cortex, and a series of latest findings made it clear how imprtant is their participation in every complex behavioral processes.

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 that makes Frontal Lobes an important device for <u>regulation of active states</u> of human behavior.

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 after the subject's attention is exhausted. Simultaneously M.Livanov from Moscow showed that each intellectual strain results in an emergeance of a complex synchronous excited points in the frontal cortex and that these synchronously working foci disappear in a passive state or after application of tranquilizes.

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

This assumption was confirmed by observations of my friend Dr. E.D.Homskaya and her co-workers made in our laboratory. A series of experiments proved that in a normal person a verbal instruction which added a special signalling function to a stimulus ("pay attention", "count the stimuli", "press the Key after the stimulus appear") result in a normal person in marked vegetative and electrophysiological changes

which can be regarded as symptoms of an orienting reflex (constriction of vessels, depression of alpha rhythm, change of 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 as well 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.

That proves that the Frontal Lobes play an important role in the regulation of active states of the brain, and that lesions of the Frontal Lobes result in an inability to preserve vigilance which is basically important for all stable decisions, preservation of plans and active regulation of behavior.

Such role of the Frontal Lobes in the process of activation explain a series of behavioral changes observed in patients with several lesions of the Frontal Lobes.

Psychiatrists know all right that patients with tumors or wounds of the Frontal Lobes become inactive, lose they

future - linked behavior and are unable to evaluate the effects of their action. They lose the ability to construct intention and to follow the programs given by verbal instructions; although they retain the instructions, they become unable to follow them and their meaningful, selective behavior is easily replaced by impulsive "field-linked" actions or passive stereotypes.

If the patient is asked to make a simples reaction, imitating the movement of the experiments, he does it all right; but if the instruction requires a re-coding of the given stimulus and the movement has to follow an intermediate program (such is the case when the instruction is given "When I lift my finger - you will show me your fist; and when I lift my fist - you will show me your finger) - The required action ~~becomes~~ is very soon replaced by primitive imitative reactions. The same can be seen if the patient ~~has~~ is asked to give a reaction of choice, lifting his right hand after a single knock, and his left hand after a double knock. It is enough to repeat this action two-three times and than to change the

sequence of signals, - and the patient ceases to give adequate choice reaction and replaces item by senselers stereotyped sequence of movements (R-L-R-L-R-L) independent from the signals.

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

If the patient with severe lesion of the Frontal Lobe is unable to follow ready-made programs given by the instruction, it is evident that he becomes totally unable to build his own plans, to select useful information and to construct a strategy of a complex behavior.

We can show that by two experiments.

It is well known that if an instruction is given to a normal person to touch with closed eyes a set of checkers, one in a form of "H" and the second in a form of "E" and to decide which of both letters is given, the subject begins with extended trials but very rapidly replaces these trials by

abbreviated process, singling out the useful information and touching only the checkers which made the difference of the two letters. That is not the case in Frontal Lobe patients. No seeking movements and no abbreviation of the process takes place, and no attempts to singl out useful information is observed; the patient continues to touch all checkers, but is unable to receive the information needed and to make the decision required. The same can be seen in an even more impressive experiment.

It is well known that evaluation of a complex visual information requires a strategy of perception, and that eye movements of the subject reflect such a strategy. It is very easy to show that recording ocular movements of a normal person during observation of simple and complicated pictures, fastening a mirror to the sclera and recording the beam of light reflected during this observation (a method proposed by A.L. Yarbuss). The records obtained show that a normal person singles out the most informative points of the picture, and when different instruction were given, - the strategy of eye

movement changes entirely.

No such process is seen in patients with lesions of the frontal lobes, and searching, meaningful movements are replaced here by senselers, chaotic or inert (stereotyped) eye movements showing that the strategy of selective, searching actions becomes impossible.

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

We can stop our analysis of the basic functional blocks of the Human Brain and their role in the organization of behavioral processes.

It is easily seen that each block takes part in the organization of complex behavioral processes, playing its own role in this organization. That is why a careful neuropsychological study of the <u>type</u> of the behavioral changes after local Brain lesions can be of a high value for a 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: can psychology be of any help in the local diagnostics of brain injuries ?

It is clear now that no complicated psychological process is localized in a definite circumscribed cortical area and that every form of complex behavior is a result of a joint work of a functional system of different zones of the brain, each of them providing its own component to the physiological bases of behavioral processes.

That has a decisive significance for the evaluation of behavioral symptoms of every local brain injury. It means, that disturbances of every complex behavioral process can result from differently located brain lesions, but each time the pathological focus eliminates one or anothes specific factor, participating in a functional system, and the <u>structure of behavioral disturbance is different</u>.

Let us show that using only one example; but this example will convince us how important is a sophisticated psychological analysis of the type of dissolution of behavioral process in case of differently localized brain injuries.

By didactic purposes we shall choose the exemple of disturbances of writing in different local lesions of the brain. That example can make it possible to show the type of the Neuropsychological analysis of a very complicated disturbance and serve us as an model of a psychological evaluation of the local brain injury.

The idea that disturbance of writing is a result of a very circumscribed lesion of the middle parts of the premotor zone of the left hemisphere - the "Exher's centre" is abandonned more that a half century ago. During the first decades of this century it became clear that writing is not at all a complex system of hand movement, that its structure is much more complex, and that practically defects in writing can be observed in cortical lesions of a very broad area of the left hemisphere. But neuropsychological observations have shown

that the kind of writing disturbances is very different in lesions of different zones of the human cortex.

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

To write down a word we have to listen to the continues flow of speech sounds and to single out separate, discrete phonemes which we have to code in letters. This is a complex process, and a good ear is not at all 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 fine, but for a person who is grown up in a culture of this language they are ~~decisive and~~ very easy distingwishable: for an Englishman "vine' ans "wine", "special" and "spatial" sound very differently and he can hardly make a mistake in their discrimination; so are the sounds "b" and "p" both in English and in Russian, and "bull" and "pull", "bark" and "park" are very different words

which hardly have some featmes in common although their acoustic difference is a very slight one.

The situation changes if we turn to phonemic systems which are different from our native language. The Russian cue of "hardness" and "soffness" is strange for the English or French language, and that is why three words totally different for a Russian (пыл - Fire, пыль = dust, and пил = he drunk) are hardly distinguishable for an English - or French speaking subject. The same is typical for the Chineese language, where the light of the pitch is a decisive cue, and where "ma˥" means "to buy" and "ma˩" means "to sell", or for one of the Cancasion languages where "antlico" means "six and "antilico" - means "seven". I can only mention that the Victnameese language where "tü" pronounced with different pitches has at least six meanings !

But the differentiation of phonemes is a task fulfilled with the participation of the cortical parts of the "acoastic analyser" - and esperially of the secondary zones of the left temporal lobe, which have intimate connections with other parts

of the "speech area"; that is why lesions of this zone result in a disturbances of the discrimination of close (or correlative) phonemes, and patients with wounds of that region become unable to discriminate such sounds as "b" and "p", "t" and "d" even in their own language, evaluating them as unsignificant variations of the same phoneme. Our observations on many hundreds of patients with local brain wounds and tumors made this discrimination of phonemes one of the most reliable tests of lesions of the left temporal lobe.

This basic defect has marked secondary results, and one of them is a severe disturbance of the writing in patients with lesions of the left temporal zone. Of an importance is the fact that these disturbances are of a very disticnt type: patients with lesions of the left temporal lobe confuse in their writing "correlative phonemes", can write "tome" instead of "dome" or "pull" instead of "bull"; they hardly can single out separate phonemes from 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 are one of the basic symptoms of such lesions in Europians, are not seen in Chineese because their writing is an ideographic and is not based on discrimination of different phonemes !

Acoustic analysis of phonemes is the first step of writing but not at all the only one.

To improve the analysis of the phonemes one has sometimes to apply additional aids, and these aids are the articulation of a sound, the 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 ?..." And when we add an articulatory analysis of the word - its structure becomes certain, and we are able to write it down.

To prove the role of the articulation in writing I asked one of my co-workers to make a special observation in a class of pupils. If you enter a class of first or second grade pupils studying writing - you can mark a noice in the class: pupils try to proneunce the words they write, and the class

is full with a buzz. It that useful are distractive ? Teachers hardly can answer this question.

To prove that I asked my co-worker to compare writing associated with such ~~bound~~ loud repetition of the words with the same process in different conditions, where we asked the child to write holding their mouth open or squeezing their tongue between their teeth. In the last cases the amount of ~~mixkar~~ mistakes in writing increesed six times !

That means that at the first stages loud articulation of the word is of a considerable help for evaluating the sounds and for writing and that only at the latest stages this component becomes less significant.

But a precise articulation requires a participation of different cortical zones, - and first of all a participation of the post-central (kinethetic) parts of the cortex of the left hemisphere. That is why in lesions of these parts we observe disturbances of precise articulations, confusion of similar (or correlative) articulemes (as "b" and "m", or "d", "e" and "n") and new difficulties in writing, - this

time in a form of confusing of writing letters which are differently articulated. In such cases the patient can write "ston" (gran) instead of "stol" (table), "khanat" or "khadat" (meaningless) instead of "khalat" (coat), - and for a trained Neuropsychologist such mistakes give a ground to suppose lesior of post central parts of the dominant hemispheres as a cause of the writing disturbances.

The process of writing begins with the evaluation of phonemes but has to go several steps further.

The next step of this process is re-coding the acoustic units of the speedh - phonemes - in visual units of the writing process - letters or graphemes. That requires the participation of different parts of the brain - especially these of visual (occipital) and spatial (parieto-occipital) zones of the cortex in close relations with the acoustic (temporal) zones. That is why the process of writing is severely disturbed in lesions of the left temporo-occipital and parieto-occipital lesions; but the type of disturbances is in these cases very different from what we have described earlier.

Patients of this group don't feel any trouble to analyse the acoustical constitution of the word, nor do they confuse their phonemic elements. But they realize marked troubles when they begin to re-code phonemes in letters or graphemes: relation of letters with sounds is often lost, and the patient begins to seen unsuccessfully the letter he needs, saying: "Oh, what is really the letter for "n" - that one, or that one ?", or he tries to find spatial relations of the elements of the letters, showing marked troubles in distinguishir the needed structure of the letter from the mirror one, or being unable to combine separate parts of the letter in a coherent whc whole. All these difficulties are clearent symptoms of lessions of the visual and spatial zones of the cortex, and they can be easily distinguished from the symptoms of lesions of acoustic or kinestetic zones. We described the first two thirds of the process of writing, and we come now to the last part of the process.

To write down a word does not mean to write a letter; it is a whole word which has to be written, and the word consists

of a sequence of sounds and letters. That is why the subject has to preserve a sequential order of the elements and to analyse its serial organization.

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

It was K.S.Lashley who found thirty years ago that spatial and sequential analysis are incompatibe processes, and that different zones of the brain are required for their organization. In special observations fulfilled during several decades we found that while spatial analysis is provided by parieto-occipital parts of the cortex, serial or sequential analysis requires participation of anterior parts of the hemisphere, whether temporal (acoustic) or premotor. That is why disturbances of fronto-temporal and the lower parts of the premotos zones of the left hemisphere, result not only in disturbances of the prosodic (rhythmical) organization of movements, but in severe disturbances of serial organization of speech and writing processes. Patients with such lesions display severe difficulties in preservation the sequence of

letters in writing, change the position of separate letters in the word, sometimes they are unable to proceed from one letter to another and often replace the needed serial order with an inert stereotype. If the lesion is located in the deep parts of the brain disturbing the normal relations of the cortex with the basal ganglia new symptoms arise - this time foreed repetition of some fragments of the letter, and 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 mostly important defect in writing ?

We don't write only letters or words; we express in writing our intention and thoughts, - and when the apparatuses of the third block of the brain are injured - and that is in cases of severe lesions of the frontal lobes, - intention and plans are disturbed, and the patient becomes unable to express his intentions and thought, both in a verbal and in a written form. I can hardly forget a letter a woman with severe lesion

of the left frontal lobe has written to the famous Russian Neurosurgeon Professor Burdenko. "Dear Professor, she wrote, I wont to tell you that I want to tell you that I want to tell you..." and ~~from~~ four pages of the letter didn't ~~want~~ go a step further !..

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We have completed the long way of the psychological analysis of the process of writing and of the symptoms of it disturbances in cases of different local lesions of the brain. It was only one exemple but we have learned important data on the style of neuropsychological analysis of this model and its disturbances in different local brain lesions.

We realized that a behavioral process can suffer in lesions of different parts of the brain, but that in different localization of the injury the type of the disturbance is different. That is why the work of the Neuropsychologist who wants to use his method for a local diagnostics of the brain lesion is not in a mere statement that the function is disturbed but rather in a qualification of the type of the disturbance, in finding the primary defect underlying this

disturbance and in description of all secondary or systemic disorders following this primary defect. We have chosen disturbances of writing as a model of such analysis; but we could as well use as an exemple the Neuropsychological analysis of perception or movement, of memorizing or concept formation, of fulfillement of a planned action or problem solving.

During last three decades we made an analysis of differences of the disturbances of all these processes in local brain lesions and we showed how a detailed description of the kind of these disturbances can be used for a local diagnostics of brain injury.

And that is the <u>basic method of Neuropsychology</u>.

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We have seen ~~koo~~ has Neuropsychology can be used as a valuable method in a local diagnostics of a brain injury. But Neuropsychology is not only an applied branch of psychology; it is a self sustained science as well; and that means that important theoretical sequence can be drown from Neuropsychological investigations.

When we say that each cortical zone takes part in the organization of behavioral processes in its own way, - we are saying that new ways to an analysis of special factors included in behavioral processes can be discovered, and that a really new approach to the factor analysis of complex psychological processes can be used.

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 complex behavioral capacities. Complicated methods of intercorrelation of the results of battaries of different tests in wast populations were used, and it is enough to remember the names of such brilliant scholars as Spearman and Thurstone, not mentioning more recent names, to evaluate all the efforts made to solve this problem.

Neuropsychology opens a new kind of psychological factor analysis, and that is a factor analysis on one person.

If a local brain lesion results in a disturbance of one of the factors included in a complex behavioral process - the

basic tone of cortical processes, the acoustic or kinesthetic analysis, spatial organization of the input or sequential organization of psychological processes - clear-cut secondary results are observed: all complex behavioral processes which include this factor become disturbed, and all behavioral processes in which this factor is absent remain intact. We know from our clinical observations that in cases where lesions of the left temporal lobe results in defects of acoustic analysis of speech sounds - perception of speech, repetition of verbal sounds, naming of objects and writing become severely damaged, but orientation in space or simple calculation remain intact. In contrary, cases of lesions of the left parieto--occipital cortex, which destroys simultaneous or spatial organization of the information is closely associated with ~~disturbances~~ of complex practical or symbolic deficites - and don't result in any dissolution of fluent speech or prosodic melodies.

That opens new vistas in the analysis of factors underlying different behavioral processes. We can easily observe

how different psychological functions are interrelated in one person, and which group of functions have common factors.

Three mean tasks become possible by using this method of analysis: we can find basic differences in quasi-similar processes; we can disover common factors in processes which at the first glance seem different; and ~~evaluate~~ we become able to ~~the~~ evaluate different inner structure of the same behavioral processes at different stages of their functional development.

Let us examine these three problems separately.

There are psychological processes which seem to be closely related if not identical in their components, although that relationship is not so easy proved. An exemple of such processes is acoustic perception of verbal and musical sounds.

Neuropsychological investigations give unexpected results: as it was shown by several authors lesions of the left temporal lobe result in marked disturbances of discrimination of phonemes while musical hearing remain undisturbed. I had an opportunity to observe during three years an outstanding Russian composer who had a haemorrage in the left temporal

lobe, suffered with severe sensory aphasia, was unable to single out verbal sounds and understand oral speech, but who cre created during these years magnificant symphonies. Doesn't it prove that there are very different factors in these two processes which seems to be so close from the first glance ?

There are some psychological problems of an opposite type. Several behavioral processes seem to be so different that one can hardly find a common factor in them. What can be in common in orientation in space, calculation and understanding of complex logico-grammatical structures ? The analysis of this problem by means of the Neuropsychology can result in a very unexpected conclusion. It is well known that lesions of the inferior part of the left parietal zone inevitably result in disturbances in orientation in space which are associated with severe defects in calculation and in an inability to understand complex logico-grammatical constructions. Doesn't it mean that these are common factors in such quasi different behavioral processes ?

A close analysis of these data show the nature of these

common factors. To make a substraction 31-7 one has firstly to fulfill an operation 30-7 = 23, and than to add the remaining "1". That is easy for a normal subject; but a patient with lesions of the inferior parts of the left parietal lobe is unable to do this: he wonders if he has to place the remaining "1" to the left or to the right of the results obtained - in other words to add or to substract it, and he fails in this operation. It is clear that other more complex arythmatical operations remain totally inaccersible to him as a result of the same defects.

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

To understand the difference between such constructions as "farther's brother" and "brother's father", "The cross under the triangle" or "the triangle under the cross", "the summer is after the spring" or "the spring is after the summer", as well such well known relational constructions as "Jenny is darker that Cate but fairer than Ann", - one has to place the elements of these construction in an inner space and to grasp

quasi-spatial relations between the alternative mentioned. That is why lesions of the inferior parts of the left parietal zones, eliminating the factor of simultaneous spatial synthesis result in disturbance of these complicated forms of verbal behavior.

It is clear that both the discovery of differences of very similar and of common factors in very different behavioral processes is of a very high importance, and we can suppose the structure of the future psychological science will highly differ from its modern structure, and Neuropsychology will play a decisive role in this development.

May we now pass to the last question which is of a high psychological interest ?

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

Does it mean that in this process the whole structure of the psychological ~~process~~ function becomes changed and that its cortical organization receives new forms ? One can hardly

answer this question by ordinary psychological ways; but for Neuropsychology the solution of this problem often becomes not too difficult.

We know all right the famous example of Gowers patient who, being instructed to repeat the word "no" said after a series of unsucsessive trials: 'No, doctor, I can't say "no"...' Cases when the patient with a local brain lesion becomes unable to fulfill a new and unhabituated task but has no difficulties in fulfilling the same action in an authomatized way are very common in clinical observations. We remember very clear an old lady who had a haemorrage in the left temporo-parietal part of the cortex and who was totally unable to write a word; but if she was asked to write a phraze very quickly, - she did it without hesitation . Cases when patients with lesions of the left temporal lobe don't write by dictation, but preserve written signatures, are very often observed in the clinic of local brain injuries. Doesn't it mean that training can result in a significant change of the whole psychophysiological structure of the behavioral process,

and that functions, which required a complex of acoustico-kinesthetic analysis now can be realized with simple motor stereotype based ~~qi~~ quite on different cortical zones ?

The problem of the essence of the functional development of behavioral processes is one of the most intriguing problems of psychology; it could be only expected that Neuropsychology will find its ways to help in answering this question.

We tried to do our best to describe 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 significance for the psychological theory.

We are sure Neuropsychology - this youngest branch of psychological sciences is standing now on terra firma and that it will find its important place in the solution of the most complicated problems of Human Behavior.

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