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LANGUAGE and BRAIN

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(Towards the Basic Problems
of Neurolinguistics)

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The problem of the relation of Language and Brain belongs to the most complex problems of science. The history of the attempts to solve it was full of confrontations of opposite approaches and often led to dead ends. The solution of this problem requires a radical revision of our basic concepts, which remained unchanged during many decades ~~— remained unchanged~~.

The difficulty of the Language-Brain problem has a following issue. Language is a product of a complex social history. It's formation took at least 30-40 thousands years; it changed significantly during much shorter periods of time, and although different Languages have some common universal rules, the phonematic, lexical, semantic and syntactical levels of language and speech underwent basic changes during several centuries. Brain had a Basic different history. So far we know it's morphological structure is a product of a very long biological evolution, and it remained relatively unchanged during the whole period after the origin of homo sapiens.

How could these two systems with a fully different scales of evolution be related?

Let us try to make a short review of different attempts to solve this problem.

Basic principles of direct localisation

The basic problem of all attempts to solve the problem of the relations of the Language and Brain was the problem of the Cortical Localization of Language and speech, it had to answer the question: which parts of the cortex are responsible for

acquisition of Language codes and of their use.[2]

Nearly all attempts to solve this problem which started in the middle 19th century had a basic assumption: they beleived it was possible to find a direct relation of Language and the brain and they tried to find direct "centra" where Language capacities (its "competence" and "performance") could be localized.

The forms of these attempts changed significantly, and different scholars used different (very often - opposite) approaches; but the basic principle of a direct relation of language and brain remained unchanged.

The attempts to find some direct localisation of language in the brain "centra" started by F.J.Gall (1810-1818,1822-1823): he was the first who supposed that some linguistic capacities are functions of circumseribed brain areas. His ideas were never accepted by scientists, and after some decades were fully rejected and forgotten. But the basic principles of his approaches remained unchanged.

When P.Broca discovered in 1861 that lesions of the posterior parts of the first frontal convolution resulted in a loss of ability to use wards - he supposed this area to be a "center" for the "motor images of speech". When C.Wernicke published in 1873 his first paper on sensory aphasia associated with lesions of the posterior part of the upper convolution of the left temporal lobe,- he supposed this part to be a "center" for the "sensory concept of words" (Wortbegriff).

It is easy to understand that the discovery of such "centra" resulted in a very short period of a series of other

"discoveries", and during the "brilland 70ieth" at least a dozen of "centra" for such abilities as reading, writing, computation etc. was made.

Scholars supposed that disturbances of some forms of speech (or some definite forms of language "competence" and "performance") can be treated as a result of a destruction of definite cortical areas or their connections, and that there is a direct relation of these capacities to some circumscribed cortical zones.

The idea that such direct relations persisted in the 20ieth century, and such Neurologists as K.Kleist (1934) and J.M.Nielsen (1946) supposed that circumseribed lesions can be responsible for such symptoms as "alexia", "agraphia", "anomia" etc. et that concepts of a direct localization or separate linguistic functions can remain unchanged.

C r i s i s

It is only natural that the idea of direct localization of complex linguistic abilities in circumscribed cortical areas brough very soan some doubts which issued partly from theoretical consideration and partly from practical observations. Several scholars supposed it highly unprobable that such complex systems as language which - from W.v.Humbold times was supposed to be the highest manifestation of the mind and which is a complex product of social history, acn be regarded as a function of small groups of neurons and "localized" in circumscribed cortical "centra". Psychologists of our time rejected the idea that speech can be understood as an immediate "faculty"; it

become clear that the acquissition of language and linguistic performances are in no way indivisible "function" and have to be understood as complex "functional systems", that they have not to be "localized" in separate zones, but rather distributed in a widespread cortical constellations or assembeies (L.S.Vygotski, 1934, 1955, 1960; D.O.Hebb, 1949; P.R.Anorhin, 1949,1955, 1970; A.R.Luria, 1966, 1970 et al).

The idea of a direct localization of language abilities came in a contradiction to some clinical observations as well.

It was Hughlings Jackson - who mentioned the basic fact that patients who are unable to name an object or to repeat a ward can use it in an unvoluntary context, and the descriptions of such patients's utterance as "No, doctor, I can't sau "no" or "Oh, I have forgotten how you call this inkstead" - can be found in all Neurological textbooks. That is why Hughlings Jackson started his well known discussion with P.Broca, supposing that Neurologists have to try to describe levels of the organization of language or mental processes in the brain rather to look for their "localization"and that the brain organization of these processes deals with their "re-presentation" or even "re-representation" on different levels of the brain.

The confrontation of the concept of a "strict localization" of functions with opposite approach appeared for a second time in the 20^{ieth} century. This time the ideas of an direct localization of functions in isolated "centra" came in a conflict with the idea of "the brain as a whole", with mentioning of the role of the mass action of the brain tissue (K.C.Lashley, 1929); K.Kleist's"strict localization" of complex function

was opposed by such outstanding Neurologists as K.Goldstein (1934, 1948) who supposed that the concept of "mass action" of the brain could be applied to the brain organization of mental function and as C.v.Monakow (1913) who mentioned that it is impossible to "localize" semantic processes, which are supposed to be functions of the brain as a whole.

The supporters of such "anti-localization" concepts supposed that their ideas are confirmed by the fact that such forms of "symbolic" activities as speach, writing, computation can be disturbed by lesions of very different parts of the brain and that these kinds of activities are never based of only one definite part of the cortex.

It seemed that such concepts found a right way in the solution of the problems of the relations of Language and Brain. But further studies showed that the idea of a "mass action" of the human brain led to a new dead end.

The modern data of neuromorphology came in a strong contradiction to the idea that brain is a homogenious, undifferenciated mass of tissue; such concepts closed all ways to a further study of the cortical organization of higher psychological processes; they came in conflict to well known clinical data,which showed that different brain lesions can result in very different forms of disturbances, and that the process of acquisition and use of Linguistic codes could suffer in a very different way in cases of differently localized lesions. We have discussed this data in a series of publications (cf. A.R.Luria, 1966 a,b, 1970, 1973 et al) and we shall return to this problem later.

Of a special interest in this context are some attempts made by one of the most outstanding Neurologist of the 20ieth

century Henry Head, who was very close to the problem we are discussing in this paper.

In his classical work on Aphasia (1926) he strongly opposed the ideas of strict localization of language and speech as it was presented by the classical "diagram makers". Following Hughlings Jackson he tried to analyse the relations of language and brain, starting from Linguistic approaches; the trouble was that his attempts to describe "nominal", "verbal", "syntactical" and "semantic" forms of aphasia and to relate these forms to some broad areas of the cortex preserved the same principle of direct relation of language and brain. That is why H.Head gave a very careful description of the kind of language disturbances in different local brain lesions, but remained unable to make even ~~some~~ a slightest approach to the analysis of their mechanisms, and his attempts - ~~perspective~~ PROGRESS in their starting motives, did not have any influence of the further development of aphasiology and after several decades became practically neglected.

The question arises: what was the cause of the failures which were permanently associated with all attempts to study the relation of Language and the Brain? What is the real source of the dead ends of the majority of these studies? We have only one answer. All we know supports our assumption that the basic principles of these approaches have to be revised, that the principle of direct relation of language and brain is untenable. We have all right to suppose that the relation of language and brain are of a different kind than the relation of elementary functions (sensitivity, vigilance), and that the classical approach to this problem came to a dead end because

all scholars - who at a first glance started from opposite positions, ~~preserved~~ followed this false idea of a direct relation of language and brain. We shall start with the idea that only a radical rejection of this assumption can result in really acientific approach to the problem we are discussing, and only the radical revision of our starting principles can help to avoid the dead ends of the classical Neurology.

Neuropsychological approaches

A radical revision of classical concept of direct relation of behavioral, processes (language behavior included) to the brain was the basic goal of Neuropsychology - a new branch of science which was created by a group of scholars, which included the present author and his collaborators (cf. A.R. Luria, 1966, 1970, 1973 et al.).

L Let us review the principal ideas of the Neuropsychological approach to the question we are discussing.

Language is a system of codes created during the long social development. This system of codes has its own structure as well as its own logics. It includes phonematics (a system of acoustic and articulatory oppositions which is the foundation of oral speech), lexics (a system of designations of objects actions and relations), morphology (the structure of words), semantics (which enables not only to desigate objects, actions and relations but to include them in different meaningful systems and correlations), and last but not least - its own syntax (a system sufficient to relate words which are able to formulate thoughts and communications). All these systems of language are a product of a long social history; they have to be adaptet by every man (to provide his linguistic competence) and applied

by
is the mans active behavior (resulting in linguistic performance).

Both linguistic competence and linguistic performance are realized by the human brain which as well is a product of a different (this time - biological and bio-social) ~~process of~~ evolution, and which is another system, constructed according different principles.

We tried show in a series of publications (such as "Higher Cortical Functions in Man", 1966, "Human Brain and Psychological Processes", 1966, 1970, "The Working Brain", 1973) that the brain can be divided into three basic functional parts. The first part (including formation of the upper brain stem and the limbic system) provides the adequate tone of the cortex and is responsible for the vigilance (cf.H.W.Magoun, 1963 et al.).

The second part (which include the posterior parts of the brain hemispheres) is an apparatus which in responsible for reception, elaboration and storage of exteroceptive information and which includes basic cerebral mechanisms of cognition.

The third part (which includes anterior gonas of the hemispheres) is a functional apparatus of programming, regulation and control of human actions; simultaneously the third functional part of the brain deals with descanding fibres which provide a regulation of the vigilance and attention, bringins the behavior in accordance with consc ious goals and motives.

It is evident that every form of human behavior is not provided by only one of this functional parts, but requires a co-ordinated work of all three functional units, each of them playing its own, higly specific role in the organization of behavioral processes.

Such functional organization of the brain is responsible for the process of acquisition and use of the codes of language, which - as it was mentioned, has its own levels and is constructed according its own logics.

It is obvious, that any "isomorphic" relation between two systems - that of the language and that of the brain - cannot exist, and that the relation of both systems can be only an indirect one.

The co-ordinated work of the brain's functional units mentioned has to provide an analysis of these codes, singling oat their decisive cues and a plastic, changable synthesis of the components of this system. Only if a well done co-ordination of all three units is preserved the acquistion and performance of linguistic structures can take place. Thus we can hardly suppose any innated parts of the brain which could be responsible and sufficient for different kinds of this linguistic processes. The mean task of Neuropsychology (and its special part - Neurolinguistics) is to single out basic components of the processes of linguistic behavior, to find basic factors, needed for their realization and to study the role which different parts of the brain play to provide these factors.

The phonological level of the language has as its base singling out basic cues of verbal sounds and providing their opposition and thus building the phonematic system of language. It is easy to understand that the central parts of the "acoustic analyser" and especially the secondary parts of the temporal cortex of the major hemisphere (which have dense groups of fibers connecting them with kinestetic parietal and kinetic parts

of precentral areas are required to provide the task of sound analysis and construction of phonemes. That is why lesions of this part of the cortex result in a disturbane of a qualification of verbal sounds and in a breakdown of "phonematic hearing" (cf. A.R.Luria, 1947,1962,1966, 1970,1973). This basic defect is in all cases associated with a series of secondary disturbances which include defect in acquistion and use of all language codes which need this ~~basic~~ process of acoustic analysis (such as understanding of words, naming, writing), while other systems, which don't include these factors (such as spatial analysis, written computation, relational thinking) can remain primarily undisturbed.

It is well known, that articulation of speech sounds is impossible without an acoustic analysis of phonemes ~~from one side and~~ as well as without a precise kinesthetic organization of the oral movements (articulemes) ~~from the others~~. It requires ~~as well~~ a system which enables a plastic transition ~~from one~~ articuleme to another which is necersary to provide a series of "Kinetic melodies".

As it became clear during the last decades these components can be provided with the help of tree different apparatus: these of temporal (acoustic), parietal (kinestetic) and premotor (kinetic) parts of the brain cortex, speaking more precisely - of the secondary zones of these areas.

It is obvious that if one of these apparatuses is injured - expressive (articulated) speech is broken down; but the type of its disturbance is in each case different. Destruction of the temporal cortex makes a selection of phonemes impossible, and results

~~ting~~ in a sensory aphasia, which ~~is~~ only secondary ~~associated in~~ evokes disturbances of expressive speech. Destruction of the lower parts of postcentral zones of the major hemisphere result in a kinestetic apraxia and "afferent" (kinestetic) break-down of articulemes with a series of secondary disturbances of speech. Disturbances of the lower parts of the premotor zone of the major hemisphere results in a breakdown of the normal plasticity of the kinetic melodies or motor skills, pathological inertia of motor excitations and thus in a syndrome of "efferent (kinetic) motor aphasia".

It is well known that a complex paradigmatic organization of semantic structure of semantic units, and the most complex semantic systems - these which are included in "communication of relations" (Svedelius, 1897) - are associated with a special form of reversible grammatical structures which have a quasi-spatial organization. (~~such~~ Constructions as "farther's brother" or "brother"s father", or "a circle under the triangee" and "a triangle under a circle" can be used as examples such structures). It is easy to understand that an acquisition and use of such logico-grammatical systems requires a participation of tertiary zones of the parieto-occipital parts of the cortex (which are the apparatus of spatial analysis and which provides a simultaneous quasi-spatial synthesis of separate components. That is why injuries of this part of the cortex result in a breakdown of acquisition and use (competence and performance) of this type of grammatical relations, whereas other syntactical forms of language which do not include such relational components (as:"the house is burning", "the doctor treated a patient") remain undisturbed, ~~as well~~ and as the acoustic and articula-

tory organization of speech is preserved. We discussed only three examples of a neuropsychological analysis of the brain organization of some linguistic processes, but these examples show clearly that a direct localization of linguistic processes in circumscribed cortical zones is impossible, and that a complicated way of a careful psychological analysis of factors, needed for different linguistic processes is required, and only as a next step singling out underlaying factors becomes possible.

That is the way of indirect approach to the problem of the relation of language and brain, which is used by modern Neuropsychology.

It includes a basic revision of classical principles of a direct localization, and it opens new roads which will avoid any dead ends typical for the classical attempts of a direct solution of this basic problem.

Psychophysiological approach

Neuropsychological analysis of language disorders associated with local brain lesions and singling out basic factors included in acquisition and use of linguistic codes,- is only one although a very important aspect of the problem of Language and Brain relations. A second aspect, although up to now a less elaborated aspect of the approach to the some problem is the ~~study~~ analysis of some physiological (or neurodynamic) states of the brain required for the acquisition and use of Language.

It is well known that both acquisition and use of linguistic codes are possible only if the physiological sts of the brain cortex provide a high selectivity and a high plasticity of the nervous processes. If these conditions are disturbed neither

an acquisition or use of very complicated phonological, morphological, syntactical and semantical systems, nor a fluent transition from one linguistic structure to another is possible.

Let us discuss both conditions separately.

As it was shown by I.P.Pavlov and his school every neurodynamic process in the normal cortex follows the "rule of force": strong (or significant) stimuli evoke strong responces whereas weak (or insignificant) stimuli - only weak responces. That provides a high selectivity of neurodynamic patterns.

From the other side - higher nervous activity requires a very high plasticity of nervous processes, i.e. a possible fast and fluent blocking of the pattern already used and a fluent transition from one excitation pattern to another. Both conditions are necessary for normal forms of mental activities included the processes underlying Language and Speech.

In pathological states of the cortex both conditions can be severely disturbed.

The first immediate result of brain injury is a significant change of the "rule of force" and as a result - a breakdown of the selectivity of nervous processes.

Pathological states of the cortex are as a rule associated with some inhibitory or "phase" - state of cortical activity which can be obsedved in a normal man only in dreamy (oneiroid) state or in a state of a deep exhaustion. On the first stage of these change - an equalization of excitation evoked by stimuli of different strength is observed: strong (or significant) stimuli or their traces begin to evoke reactions equal, to the reactions to the weak (or insignificant stimuli, or their tra-

cesy. On the next - paradoxial-stage weak (or insignificant) stimuli (or their traces) begin to evoke even stronger reactions than strong (or significant) stimuli (or their traces). That means that the selectivity of every mental process becomes severely disturbed: secondary or insignificant associations are evoked with the same probability as the principal or significant association, and an organized intelectual process is no more possible. Everyone can observe that during his dreamy (oneiroide) states, and it is very probable that this physiological mechanism can explain the process of dreams much better than it was done by Sigmund Freud.

Such change of the "rule of force" are evoked in pathological states of the cortex following brain injuries when the neurodynamic processes can lose their organization according the "rule of force", and when an organized, selective flow of nervous processes can be highly disturbed.

The same can be said concerning the plasticity of the nervous processes.

Whereas in normal states of the cortex a fluent transition from one neurodynamic pattern to another is very easy,- in pathological states of the brain such plasticity can be highly disturbed, every excitation becomes pathologically inert and a fluent shift from one pattern to another is no more possible.

Both disturbances can be as well of a general or of a partial (regional) type. The last can be observed in brain wounds, tumors, regional inflammations or some vascular disorders (hemorrhages, vessel constrictions, embolisme).

It is easy to observe that such regional pathological

disturbances of neurodynamics can result in marked disturbances of acquisition and use of linguistic codes, which require a highest degree of selectivity and plasticity of the nervous processes.

It such pathological states are limited by the convexital parts of the left temporal zones of the cortex - the system of highly selective phonematic opposition is broken, - secondary phonemic cues are evoked with the same probability as the basic ones, and a breakdown of the paradigmatic organization of the phonematic level of linguistic codes is observed; that is typical for the syndrome of sensory (or acoustic) aphasia, with many confusions of similar phonemes and "literal paraphasias".

It such pathological states are limited by the tertiary zones of the temporo-parieto-occipital cortex-similar disturbances of selectivity can be observed on a higher, semantic level. In patients of this group who try to find a word a very peculiar situation can be observed. A whole net of words is evoked with equal probability; a part of these words has some phonematic, another part - a semantic similarity with the word needed, - and the phenomenon of "amnestic aphasia" with "verbal paraphasias" occures, which is really not a result of forgetting of words, but rather the result of equal probability of evokation of a whole complex of words which have any similarity. As an example we can mention a case when such in a patient trying to find the word "Hospital" (in Russian - "Bolnitsa") a series of words with some similarities were evoked, such as "Militsia" (phonematic similarity of suffixe "-tsa" and of meaning - a public organization) - ... School (semantic similarity - public

organization) - "Red Army" (via association with "Red cross organization") etc.

Such a loss of selectivity in the finding of a word is well known in cases of a search of Family names where a "tip of tongue phenomenon" analysed by R.Brown & J.Mac Neal (1966) was described. The present author remembers a case when trying to find the name of a famous Georgian painter "Pirosmanishvili" he found successively evoked names "Prangishvili" (a Georgian psychologist), "Passanauri" (a Georgian village) etc.- all interconnected by a complex of features: Georgian names - begining with "P", the same double structure (base + suffix) etc. The same phenomenon of a loss of selectivity of semantic system was studies by objective methods in brain damaged children where a prevalence of phonetic similarity over semantic similarity was observed (A.R.Luria and O.S.Vinogradova, 1959).

Similar defects are observed in a loss of normal plasticity of nervous prosesses which takes a form of a pathological inertia or perseveration of patterns. This symptom is observed in lesions of the lower part of the premotor zone of the left hemisphere in cases of the "effernt motor aphasias" which result in a pathological inertia of articulation patterns, and when a morphological pattern of the word evoked becomes so inert that the patient is unable to make a shift to the next word (cf. A.R. Luria, 1966 a & b, 1970, a & b, 1973 et al.).

If the lesion is situated in the region of the left temporal zone - similar loss of flexibility can be observed in sensory processes, and "perseverative verbal paragnosias" can appear (although this symptom is less experesses that perseveration

of motor patterns in lesions of the anterior parts of the brain).

Needless to say that all phenomena, evoked by regional pathological states of the cortex are invaluble for a series of linguistic studies, and that all these disturbances can be used as a method of an analysis of similarity and stability of some linguistic structures.

These studies are now on their very beginning, but it is no doubt that this method will find its evaluation very soon.

The significance of Neurolinguistics for Linguistic studies

Up to now we discussed the significance of Neuropsychology for a refining of our concepts of the relations of Language to the Brain. It is very important to mention that these studies have a high significance for the further development of the linguistic as well. It is well known that linguistics which during the last decades developed to the level of one of the most precise sciences equal to natural sciences and mathematicly is feeling hardly a lack of propper methods of investigations.

In classical linguistics these methods were limited by fragmentation and comparative studies. The new transformational linguistics added some new methods of generative grammar which brough linguistics to a new level.

But nevertheless - one of the most significant methods of linguistics - as N.Chomsky mentioned many times - remained the method of intuition or immediate knowledge, which up to now is the mean method for studying linguistic "competence" and partly of "performance" (N.Chomsky, 1957, 1965, 1962,1972).

It is only too evident that every new objective method in the study of language can ve highly welcome. Only such methods could provide a scientifically based analysis of the basic component and types of linguistic structures, their development and dissolution as well as the relative constancy of their patterns.

One of such objective methods can be seen in observations dealing with language development in children; a series of most important works done by R.Brown, T.Bever, J.Fodor ,W.Leopold, D.Slobin et al. during the last decades made an invaluable contribution to the application of this method.

The second of such objective methods was that of an attempt to apply some psychophysiological technique for an objective study of semantic systems. We tried to do this in some researches following the early studies of Razran (Ries, 1940 1949) (cf. A.R.Luria and O.S.Vinogradova, 1959, 1971) and we shall not dwell on this attempts further.

There remains the last group of objective method for studying linguistic structures. That is the method of Neuropsychological (or one can say Neurolinguistic) approach to the language phenomena.

As we have already told every focal cortical lesion of certain zones of the major hemisphere results in a deterioration of certain factor underlying the acquisition and use of linguistic codes. These factors play different roles in the organization of different linguistic structures.

That is way a careful study of the type of the breakdown of these structures in different localization of brain lesion can be applied as a new objective method for an objective study of the linguistic structures and their different levels.

We have already mentioned that lesions of the outer parts of the left temporal zone from one side and of the lower parts of the left postcentral zone of the cortex from the other side result in a marked breakdown of the phonematic and articulatory oppositions. It is quite easy to understand the value of a carefully analysis of the basic rules of the confusions of phonemic and articulatory opposition in these cases to enable further steps for an objective analysis of the mean structures of this level. We tried to do this work in a series of publications (A.R.Luria, 1970,1973, E.N.Vinarskaya,1971) and we see clearly all results which can be brought by such investigation.

We mentioned as well the kind of important data which can be obtained by a careful study of the complex semantic strustures of verbal communications associated with lesions of the tertiary (temporo-parieto-occipital) zones of the major hemisphere. We have seen that such lesions which evoke a breakdown of processing of spatial (and quasispatial) relations result in a certain split in understanding of complex logico-grammatical structures: all linguistic structures which include logico-spatial relations and which are based on reversible patterns (such as "father's brother" and "brother's father" etc.) are broken down and become unanderstandable (cf. A.R.Luria 1946,1947,1966,1970, 1972); all linguistic structures which don't include this factor and which deal with "communication of relations" remain preserved. Doesn't that mean that a careful Neuropsychological (or Neurolinguistic) analysis opens new vistas for an objective study of complicated linguistic structures? We have to mention a last opportunity which - last but not least - opens new roads for

the problem of the Brain mechanisms of linguistic processes and is of a very high significance of the linguistics.

As it was mentioned by R.Jacobson (1955,1956,1964,1966, jointly published in 1971)- lesions of the anterior parts of the hemisphere result in a marked deterioration of syntagmatical organization of verbal communications while the paradigmatical organization of the linguistic codes remain relatively preserved. In contradictinction, lesons of the posterior cortical areas of the major hemisphere result in a breakdown of paradigmatical organization of linguistic structures of different levels (phonemic level in lesions of the posterior parts of the left temporal lobe, articulatory systems in lesions of the lower part of the left post-cortical zone, semantic- or logico-grammatical level in lesions of the posterior tertiary zones), whole the syntagmatic organization of the fluent speech remains preserved (cf. as well Benson, 1967, D.Howes and N.Geschwind 1964, H.Goodglass, 1968, Kerschensteiw, Poeck and Brunner 1972 et al). These data (which I shall discuss in details in my forthcoming book "Basic Problems of Neurolinguistics") are of an utmost importance for further linguistics investigation. They show how two aspects of language - unseparable in normal speech - can be separated in brain pathology, and it is needless to say what important perspectives does this open for the linguistic science. In his "Lectures on the work of the Brain Hemispheres" I.P.Pavlov mentioned once, that pathology can separate and simplify all what is united and ~~inaccessible~~ unseparable in normal processes (lecture 18),- and that statement can be in a high degree applied to the Neuropsychological studies of the Brain organization of Language and its significance for Linguistics.

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