A. R. LURIA

-

BASIC PROBLEMS OF NEUROLINGUISTICS

MOSCOW
1969

BASIC PROBLEMS OF NEUROLINGUISTICS

A. R. Luria

Problems

A new branch of human sciences has developed during the past few decades bordering both social and natural sciences which might be called 'neurolinguistics'. A century of work preceded it but it has only recently assumed its definitive form. We propose to deal with a few assumptions and facts about neurolinguistics limiting ourselves, for the most part, to the data obtained in our laboratory in the past thirty years.

It is well known that the basic forms and component parts of speech -- the phonic form of speech, the grammatical and semantic structure of a word, and also the syntactic structure of a whole sentence -- were formed during a long social and historical process and are the subject matter of a number of sciences (phonetics and phonology, speech morphology, lexicology, syntax, and semantics) constituting the different branches of a vast area of science -- linguistics. It is also known that all these forms of speech are expressed in living human speech by means of an appropriate system of sounds consisting, according to certain laws, of lexical units -- words -- and forming a cohesive, explicit statement. Furthermore, this statement is formed in a complex process beginning with a total project (a thought underlying the statement), passing through the stage of internal speech (or summary pattern of the sentence), and codified (or realized) in explicit speech. For the one who is ~~hearing,~~ listening, this ~~statement~~ process takes a reverse course beginning with receipt of the information, followed by decoding -- separating its essential informational units -- and ending with a total conceptual plan experienced as the 'understanding' of the message. Linguists, some of whom are world famous, and many psychologists (among them such outstanding figures as K. Buhler, L.S. Vygotskiy, and more recently, G. Miller, R. Brown, D. Broadbent, et al) have studied the various aspects of this process. The joint efforts of these scientists have been directed towards breaking down the unified and continuous flow of speech into its component elements and getting down to the essential mechanisms of the speech process.

However, this latter task has been far from easy. In a normal statement, all aspects of the speech process seemed to be so merged and so homogeneous that it was not always possible to break them down into components or to discover the underlying elements.

For this reason, many researchers directed their attention towards an area which might seem to be of very little help, but which began to play an increasingly important role in the solution of these problems -- to the pathology of speech and, in particular, -- to neurology.

The great Russian physiologist, I.P. Pavlov, pointed out that "pathology, by breaking down and simplifying, often reveals to us that which is hidden, that which exists in the latent and complex state in normal physiology". (I.P. Pavlov, 1949, Vol. IV, 18th lecture). It is for precisely this reason that the study of those changes which obtain in physiological processes due to pathological conditions of the brain has caused so much interest and has been used as one of the ways of analyzing normal physiological phenomena.

History

As we have already indicated, attempts to use the data from brain lesions for analyzing speech processes were begun long ago -- over a century.

In 1861, the French surgeon and anatomist, P. Broca, established for the first time that a lesion of the rear third of the lower frontal convolution of the left cerebral hemisphere caused a disorder in the ability to pronounce a word, although the movements themselves of lip, tongue, and larnyx were not affected. This fact enabled him to make the assumption that localized lesions in this area of the brain made it possible to isolate the mechanism underlying the "motor patterns of speech". Within thirteen years -- in 1874, the German psychiatrist, C. Wernicke, made a second discovery: he demonstrated that a lesion in the rear third of the upper temporal convolution of the left cerebral hemisphere disturbed speech perceptions without, however, affecting the ability to independently pronounce words and phrases. This made it possible for him to identify 'sensory patterns of the spoken word', which he erroneously termed 'verbal concept' (Wortbegriff), which was based on the perception of speech sounds specific to language. This was a significant step in analyzing brain mechanism.

At about the same time, the well-known English neurologist, Hughlings Jackson (1866-78-79) was conducting his research. Based on his observation of the pathology of speech arising during localized brain lesions, he stated his thesis that a speech unit is not so much an isolated word as a whole statement and that it is precisely such a statement (propositionizing) which is disturbed in localized brain lesions. His successor -- the German psychiatrist A. Pick (1913, etc) -- isolated a special class of speech disorders which he called "agrammatische Sprachstörungen". It can easily be seen how these discoveries led to a careful study of that syntactic unit of the sentence which only later in the works of a number of outstanding linguists was defined as the basic component of living language.

Subsequent research on the part of a number of outstanding neurologists and psychiatrists from different countries confirmed an important fact: it would seem that the variously localized lesions of the left cerebral hemisphere disturb different aspects of speech. Many authorities have shown that a lesion in the temporal areas of the left hemisphere disturbs the receptive aspect of speech while a lesion in the posterior parts of the ~~post~~-frontal areas disturbs speech expression, and a lesion in the parietal-occipital regions disturbs speech which has a complex semantic structure etc. Some authorities have attempted to describe the lesions causing disorders in the "verbal", "nominative", "syntactic", and "semantic" organization of speech processes, isolating those parts of the cerebral cortex, lesions of which have caused these disorders in the different aspects of speech (H. Head, 1926). Even other authors have attempted to trace in detail those psychological and physiological laws which underlie the disintegration of complex speech levels resulting from localized brain lesions (Isserlin, 1929-32; Lotmar, 1915, 1935; Ombredane, 1951 etc).

All these attempts have made it possible to accumulate a great deal of documentation describing those multiple forms of speech disorders caused by localized brain lesions, and have amply demonstrated that cerebral pathology is definitely in a position to break down those complicated speech formations which, under normal conditions, do not lend themselves readily to separate study.

However, all these facts of clinical neurology were only a preliminary stage in the creation of this new branch of science which we might call by the term "neurolinguistics".

To convert these facts into explanatory principles, it was necessary for linguistics itself to pass from the descriptive period to an exact analysis of the basic units of speech and for us to see the physiological and neuro-psychological mechanisms underlying the clinical descriptions of speech disorders.

Formulation of this work was begun only in the last few decades. It has embraced a number of aspects of modern linguistics which will be the object of further study.

Phonetic?

Neurolinguistic Analysis of the Phonic Structure of Speech

We shall first deal with the data obtained by neurolinguistics in an analysis of the phonic structure of speech and its principal mechanism.

Since the time of the classical studies of N. Trubetskoy (1939) continued by R. Jakobson (1942), it has been known that speech consists of a system of elementary units -- phonemes -- built according to a pattern of phonological opposites. It has also been known that specific signs -- different in different languages -- are the basis of these opposites and that, in addition to the classic opposites of sounds (loud/dull, soft/hard etc) typical of the Russian language, a number of other opposites can be distinguished.

The question then arises: which cerebral mechanisms supply these opposites? Is it not possible, by means of special neurological studies, to identify a number of isolated psychophysiological factors underlying them?

In their day, a number of Soviet researchers (R.M. Boskis and R.E. Levina, 1938) demonstrated that when children have aphasia (congenital under-development of speech associated with cerebral deficiency) they may be unable to distinguish contrasting phonemes (b/p, d/t), although the distinction between disjunctive phonemes remains possible. Later, based on documented observations of localized cerebral lesions it was shown that these disorders of phonological hearing occur because of injuries, tumors, or hemorrhages upsetting the normal functioning of the posterior upper zones of the left temporal area (A.R. Luria, 1947); these patients remain able to distinguish and repeat very different sounds (such as R and T, M and K), but they are unable to distinguish, or correctly repeat, contrasting phonemes, confusing these phonemes both in pronunciation and in writing, nor are they able to form differentiated conditioned reactions to pairs of contrasting sounds (A.R. Luria, 1947; 1963; A.B. Kabelyanskaya, 1947 etc). When lesions in this area were more severe, the defect in phonological hearing became more acute, and the patient was unable to distinguish even many of the disjunctive phonemes. However, a lesion in other parts of the cerebral cortex did not result in any such deficiencies.

In Figure 1 we see the results of a study made of ~~phonological hearing~~ in a large number of patients with lesions in the left hemisphere.

We see from this that only lesions in the posterior-upper zones of the left temporal area and adjacent areas result in a disorder in the ability to discriminate ~~repeat~~ similar (opposition or correlated) phonemes.

Fig. 1. Impairment of phonological hearing in patients with lesion in the left hemisphere.

This fundamental fact shows that opposite ~~neighboring~~ phonemes are distinguished through participation of the cortical apparatus of the auditory analyzer or, to be more precise, the secondary zones of the left temporal area which, by their very cyto-architectural structure (pronounced development of "associative" layers which participate in the work of the projection and reception layers of the cells) and by their very anatomical connections (very developed fiber bunches connecting the auditory cortical area with the lower zone of the parietal region and of the posterior frontal region (S.M. Blinkov, 1955)) are instruments especially adapted for analyzing and synthesizing speech sounds.

It is natural that a lesion in the posterior upper zone of the left temporal area (in right handed people), resulting in impairment to phonological hearing, causes a group of defects in those speech processes, the normal flow of which depends upon maintaining phonological hearing and which are contained in the syndrome of so-called sensory or acoustical-gnostic aphasia.

Patients with this syndrome are unable to distinguish ~~neighboring~~ opposite (correlative) phonemes and, therefore, are unable to immediately recognize pronounced words. To them, the word "golos" may sound like "kolos" or "kholost", or "kholod", and the word "lokot'" may sound like "rokot" or "rokhod'", and naturally, when the heard word is not clearly perceived, they undergo an emotional experience which has been called "alienation of word meaning".

Patients who suffer from this form of aphasia and who have gradually recovered describe this unique emotional experience as one in which they perceive speech sounds like a "rustle of leaves", or the "babble of a brook". This shows that the basis of this disorder is not partial deafness (as was thought in the dawn of learning about aphasias), but impairment of articulate, trained phonological hearing.

It is interesting that at the height of the syndrome of acoustical-gnostic aphasia, the phenomenon of "alienation of word meaning" is so resistant that constant repetition of the same word does not improve and even worsens his understanding, and degeneration of the decoding of hearing-speech information remains one of the most resistant symptoms.

In instances of relatively more severe forms of temporal, acoustical-gnostic aphasia, the phenomenon of "alienation of word meanings" obtains if the patient is shown three objects in succession and these objects are named again and again in series, for example: "eye", "nose", "ear", "nose", "eye", "ear", etc., or -- which shows an even more pronounced defect -- when they are named by pairs ("eye-nose"; "ear-eye"; "nose-ear" etc). In these cases, the patient very rapidly loses the correct pronunciation of the word and begins to experience considerable difficulty in understanding their meanings, saying: "nose-...nose...nosh...and what is this?...".

No less pronounced in these cases are the difficulties in repeating words and in naming articles they have been shown.

In attempting to <u>repeat</u> a word, the patient in this group easily begins to mix up ~~neighboring~~ correlative phonemes, reproducing "sobor" (cathedral) as "zabor" (fence) or "zapor", and they cannot break down the sequence of consonants repeating "Pskov" as "Psov" or "Vsov", or "Poskov" and giving abundant "literal paraphasias".

They experience great difficulty in <u>naming objects</u>, which becomes very apparent when they attempt to find a relatively rarely used term; for example in attempting to say "lokot'" (elbow) or "zaponka" (cufflink), they begin their search by saying "kogot'...nosot'...rosot'...: or "zakuna...zapuka..." etc. <u>Prompting does not help patients in this group whatsoever</u>, and this fact plus the continual search for the word convinces us that defects in the phonological ~~layer~~ organization of words form the basis of these difficulties.

These patients have very distinct disorders in <u>writing</u>. They are quite able to write out very simplified stereotypes (for example -- their name), and they can copy text but when they attempt to write down a word which has been dictated, they begin to mix up ~~neighboring~~ correlative phonemes experiencing difficulties in breaking down the component elements of the word with the sequence of consonants, and their writing becomes a chain of agonizing attempts. Figure 2 shows examples of these disorders.

Fig. 2. The writing of a patient with temporal (acoustical-gnostic) aphasia.

It is characteristic that degeneration of the phonological structure of words does not necessarily cause these patients to have any impairment of the prosodic and intonation-melodic side of speech, and patients who lose the ability to adequately pronounce the phonemes of a given word retain the ability to reproduce the intonation and prosodic structure of a word by filling it with completely inadequate sounds.

However, subsequent research has shown that the temporal cortical areas (hearing-speech) are not the only cerebral parts involved in phonological analysis.

From observations of early ontogenesis of speech (the same as in the early stages of writing) it is well-known that pronunciation plays an important role in discrimination of speech sounds, and that, without articulatory reproduction of speech sounds, it is impossible to distinguish them clearly and to associate them with specific categories -- an operation which is typical of phonological hearing. As the observations of L.K. Nazarova (1952) have shown, one only had to omit, in first and second year pupils, the articulation of a word which they were to transcribe and it became impossible for them to distinguish clearly the necessary sounds, and their writing degenerated. R.E. Levina (1940) obtained analogous data demonstrating impairment of writing when defects are present in the motor centers of speech.

These facts make it necessary to assume that kinesthetic analysis of speech sounds plays an important role in phonological hearing. Neurolinguistic analysis has confirmed this supposition. It has been found that lesions in the lower regions of the post-central region of the left hemisphere, causing a syndrome of highly localized kinesthetic disorders, brought about impairment in the articulation of kinesthetically similar sounds, but also resulted in the fact that the patient began to have difficulty in discriminating phonemes similar in pronunciation ("articulemes") and to make typical errors in writing, confusing b/m, d/l etc. and writing "khalat" as "khadat" and "ston" as "stol" or "slon" etc. (A.R. Luria, 1947, 1950). Similar difficulties were found in attempts to bring about conditioned motor reactions to sounds similar in articulation.

Figure 3 shows typical examples of the writing of patients suffering from afferent motor aphasia.

Fig. 3. Writing of patients with "afferent motor aphasia".

It is easy to see that the nature of the mistakes which these patients make is quite different from those which are seen in the writing of patients with temporal, acoustical-gnostic aphasia.

These observations, recently confirmed by Leongardt (1964), have made it possible to show that the kinesthetic factor enters into the auditory analysis of speech sounds. At the same time, they have made it possible to break down the system of phonological oppositions by the neurolinguistic method, defining the oppositions as phonemes (in the narrow sense of this term) which are distinguished in hearing and as articulemes which are distinguished kinesthetically. There is every reason to think that subsequent neurolinguistic analysis will make it possible to determine, to an even finer extent, the place of both factors in the formation of the phonological system of a language.

These principal discoveries have made it possible to establish the known factors which make up the phonological system, and to indicate the various cerebral cortex mechanisms ensuring their formation. Subsequent neurolinguistic research, conducted in the last few years by E.N. Vinarskaya, has made it possible to approach these phenomena by analyzing the different levels which lie at the basis of the phonological system of a language.

As the work of L.A. Chistovich (V.A. Kozhevnikov and L.A. Chistovich, 1965) has shown, the processes ensuring perception of speech sounds may ~~obtain~~ be observed on different levels. The most elementary level may be designated as the level of sound imitation; it appears in the rapid reproduction of any (even if they are not phonological) sounds; it obtains with minimum latent periods (up to 200 thousandths of a second) and does not require any fine analysis of these sounds with relation to their specific category. The more complex level of the sound perception process manifests itself in the precise ~~chronological~~ categorial classification of sounds and their relation to a specific category. Naturally, this requires more time (up to 400 thousandths of a second), and it is clearly manifested in an experiment when the subject is asked to relate a given sound to a specific letter.

From the recent research of E.N. Vinarskaya (~~1959 and~~ unpublished data), it was shown that the cerebral mechanisms of these two levels of receiving and ~~treating~~ coding of the phonic information are not identical. It was found that, in a number of cases of localized lesions of the left hemisphere, a selective disorder of only the imitation of speech sounds can be observed while, at the generalized level, perception of these sounds remains quite intact. At the same time, the observations showed that localized brain lesions can cause the reverse syndromes whereby patients retain only the imitative level of linguistic activity while all forms of speech sound analysis on a generalized (phonological) level ~~degenerate~~ is disturbed. Research, conducted by E.N. Vinarskaya, has shown that specific structures of the parietal-temporal area of the left (dominant) hemisphere, which are selectively responsible for the different functional levels for conversion of speech sounds, can evidently be identified.

These facts show that neurolinguistics will be afforded a new opportunity to describe the two levels ensuring proper functioning of a phonological language system, namely, the level of auditory receptions which ensures the simplest imitation of sounds, and the more complex level which makes it possible to classify sounds. Neurolinguistics can also make it possible to define the participating physiological mechanisms and to point out those cerebral mechanisms most actively participating in them. There is no doubt that these neurolinguistic studies, begun only in the last few years, have made it possible to take a new essential step in the study of the questions posed above.

So far, we have talked only about those cerebral mechanisms which ensure identification and pronunciation of specific speech sounds forming the physiological basis of the phonological system of speech.

However, it is quite clear that these facts make up only part of the neuropsychological analysis of the phonic aspects of speech. We know that phonemes unite to form complexes (syllables and words) and that their phonetic characteristics change depending upon the position which a specific phoneme occupies in a syllable or word. In some instances, these changes mean that a number of phoneme signs change depending upon the sound following them (anticipation changes of a consonant in relation to the consonant that follows resulting, for example, in the different sounding of the phoneme "T" in the syllables "tu", "to", "ta", "te", "ti"). In other instances, they manifest themselves in the smooth passage from one phoneme to another ensuring phonetic continuity in the pronunciation of a whole word. Both processes require a <u>harmonic commutation</u> from some audio-articulatory signs to others overcoming, to some extent, the discreteness of isolated phonemes which are indispensable to harmonious speech.

By what mechanisms are these processes effected?

Neurolinguistic analysis points up the facts answering these questions.

Even in a series of articles published long ago (A.R. Luria, 1947, 1948), it was shown that harmonious passage from one movement to another with inhibition (denervation) of the preceding link, and anticipation of the next link is effected by immediate participation of the pre-motor cortical areas, a lesion in which causes a disturbance of the "kinetic melodies" and degeneration of motor habits (see also A.R. Luria, 1962, 1963; E.G. Shkol'nik-Yarros, 1966 et al). As their observations showed, this role played by the pre-motor cerebral areas is not limited to the synthesis of the harmonious movements of the hands but may also appear in the speech processes. Thus, a lesion in the lower areas of the pre-motor zones of the left hemisphere may leave specific articulemes intact, but the passage from one articuleme to another becomes impossible; the pathological inertia of nerve processes in the motor sphere, typical of these lesions, does not allow the patient to pronounce a whole syllable or a single word even though he remains able to pronounce isolated articulemes.

The picture of afferent motor aphasia has been quite well studied and its symptoms have been very clearly documented. A patient with this form of speech disorder, which arises as a result of a lesion in the anterior areas of the speech zone (posterior third of the upper frontal gyrus of the left hemisphere or the so-called "Broca's gyrus"), can easily repeat isolated sounds without showing any difficulty in finding the necessary articulation and without confusing "opposition articulemes" (as "b" - "m" - "p" or "d" - "l" - "p"). However, they begin to experience intense difficulties when they are asked to repeat a series of two or three syllables in which only one vowel changes (for example: "bi-ba-bo" or "bo-ba-bi"). Once they are given one articulation, they are unable to switch to another and are stuck on the first articulation, pronouncing "bi..bi..bi..." or, after having successfully pronounced one series of "bi-bo-ba", they cannot switch to the second and they continue to repeat without variation "bi-bo-ba...bi..bo...".

Similar difficulties are encountered in attempting to pronounce a whole word. In attempting to repeat the word "mukha" (fly), they pronounce the first syllable "mu...", but they cannot switch to the next syllable continuing to helplessly articulate "mu...m...ma...". The only way to help them master articulatory switching is to put both syllables into sharply different contexts and to suggest that they say "mu" ("like a cow moos") and "kha" ("like a man laughs"). Only in this way -- after a well-known exercise -- are they able to pronounce this word.

Even greater difficulties arise in patients of this group when they try to repeat a series of words or a sentence.

Thus, whereas such a patient with a less pronounced form of efferent motor aphasia is able to repeat the words "dom-stol" (house-table), he will repeat the next group of words "kot-igla" (cat-needle) as "dom-igla" (house-needle) or "dom,stol...no...kot-stol" (house, table...no...cat-table); the repetition of three succeeding words in series is usually often impossible, and the patient repeats the words "dom-noch'-kot" (house-night-cat) as "kot-noch'...kot" (cat-night-cat).

Patients in this group also have the same difficulties in naming objects. These patients frequently do not experience any great difficulty in selecting the first word (in contrast to the patients with lesions in the posterior regions of the speech zone whom we will discuss later). In the most difficult cases, when they name an object, they experience the very same difficulties in the harmonious passage from one articulation to another as we have already described. In milder cases (or in lesions located in front of "Broca's gyrus") they are able to pronounce one word, naming the objects, but are unable to switch to the next word when they must name the next object. These difficulties become very apparent when they attempt to name a pair of objects; thus, after they have successfully said "nozh-ochki" (knife-glasses), when they are given another pair of objects (for example -- butylki and yabloki (bottles and apples)) they again repeat the words "knife -- and these are glasses!" or "bottles -- and these are glasses...", they are unable to overcome the stereotype which has arisen. Pronounced disorders occur in the writing of these patients.

In the worst cases, such a patient is unable to maintain the necessary position of a letter in a word putting the strongest articulemes in front (for example, a patient will write "okno" as "kono") or, since he is unable to pass from one word to the next, after he has correctly written the word "nos" -- he writes "zub" as "zos", "sok" as "vos" etc. (Figure 4).

Fig. 4. The writing of a patient with efferent motor aphasia.

When a cerebral lesion is located within the lower regions of the pre-motor zone and disrupts normal relations between the cortex and the subcortical motor units, the disorder in the writing takes on a different character, and the patient begins to listlessly repeat individual strokes, maintaining the structure of the whole word (Figure 5).

Fig. 5. Motor perseverations in the writing of patients with deep lesion in the lower regions of the left pre-motor region.

It is typical that whereas in patients with lesions in the temporal area, the rhythmic-melodic structure of their speech remains intact, while in patients in the group just described, it is severely destroyed, and their speech takes on an unpronounced ~~"scanning~~" nature. / interrupted (or jumping)

Even, with the reverse of this syndrome, defects in the rhythmic-melodic structure of their speech remains quite apparent, and the patient who has been asked to say a sentence with varying stress (for example -- "I am going to the movie" and "I am going to the movie") is unable to do this. The writing of the accented wave of both sentences of the normal subject and patients with "afferent" and "efferent" motor aphasia shows this quite clearly.

Fig. 6. Changes of accent in speech requiring different pronunciation of a sentence in a normal subject and in patients with "afferent" and "efferent" motor aphasia.

It is quite easy to see that neurolinguistic analysis reveals here the mechanisms underlying the ordering of speech sounds into harmonious sequences; obviously, subsequent research will make it possible to have a more detailed analysis of those processes which ensure the harmonious intonation-melodic structure of the speech processes.

<u>Neurolinguistic Analysis of the Lexical Structure of Speech</u>

In speech psychology there is a simplified concept according to which the lexical units of speech -- words -- are the result of a direct association between conditioned sounds and the ~~graphic shapes~~ images of objects.

According to these concepts -- the ~~shape~~ image of an object does not immediately evoke an associative word, but the heard word does immediately call up the corresponding image of the object designated by this word.

Such ideas were acceptable when simplified ideas of association dominated in ~~science~~ psychology; however, they have long ceased to correspond to modern concepts of the flow of psychic processes and now they need to undergo a fundamental re-examination.

According to modern concepts, words reveal a multidimensional association with each other and form a single complex network or matrix consisting of verbal designations associated with each other for different reasons.

A number of such symbols are:

(a) semantic associations, according to which words which are part of the system of one total concept and words designating objects which make up one total situation are associated with each other.

> Thus, the word "loshad'" (horse) can be linked with the words "korova" (cow), "ovtsa" (sheep), "sobaka" (dog) through the category of "domestic animals" and with the words "volk" (wolf), "medved'" (bear), "lisa" (fox) through the more general category of "animals"; with the word "oves" (oats), "seno" (hay), through the category of food; with the words "ekipazh" (vehicle), "telega" (cart) through the category of work etc.

(b) sound associations, by which a word is linked with other words similar in sound.

> Thus, the word "koshka" (cat) can be linked with the words "kroshka" (crumb), "kryshka" (cover), "kruzhka" (mug), or the word "skripka" (violin) with the word "skrepka" (clamp).

(c) morphological associations, by which a word can be linked to other words similar in morphological structure.

Thus, the word "tele-tayp" (teletype) can be linked to compound words "tele-graf" (telegraph), "tele-fon" (telephone), "mikro-fon" (microphone) etc. which are morphologically similar.

Under ordinary circumstances, semantic associations of words dominate, and the heard word does not cause words to arise in the memory which are similar in sound or morphologically.

However, this rule can be easily broken in two cases: when the word does not have any clear-cut meaning as an object and when a man is in a situation which is unusual for him (extreme fatigue). Abnormal conditions (pathological cerebral conditions associated with underdevelopment or illness) belong to the latter category.

Difficulties in finding the necessary word and errors in naming an object may clearly reveal the complex structure of those associative systems (or matrices) of which each word is a part.

Let us first discuss examples indicating how difficulties in remembering a necessary word arise in a normal person.

Remembering names is a very ~~graphic~~ and well known example of difficulty in remembering the necessary word.

Names are just such examples of words in which the system of semantic association does not have any key meaning and in which semantic associations may be equal to sound and morphological associations, and it is precisely this fact that makes it difficult to find the word.

In literature we have seen examples of the forgetting of names which results in a replacement of the name with words associated with it. Sigmund Freud described the difficulty which he experienced in remembering the name ~~"Sin'orelli"~~ (Signorelli), and he saw the reasons for this as emotional factors. In his story "Loshadinaya Familiya" (A Horsey Name), Chekov cited the example of forgetting the name "Ovsov" which had been overshadowed by very strong ~~graphic~~ visual associations.

Let us limit ourselves to two more examples.

In writing these lines, I had difficulty in remembering the name of the Georgian primitive artist "Pirosman" (or "Pirosmanishvili"). Attempts to remember this name surfaced words like "Passanaur", "Aznaur" (due to the principle of compound structure and "truncated" structure), "Prangishvili", "Kuchishvili" (because of names with a Georgian ending -- "shvili", familiar to the author), "Tsinondali" (compound and a well-known Georgian word). The author could avoid these difficulties only by thinking of the name "Pirosman" in the sense of "Ogon'" (fire) ("pyrotechnics") and "Turki" ("Turks") ("Osmany") (Osmans). The author experienced difficulties in remembering the name "Wilkinson", which was replaced with the names "Sverde-ruk", "Steven-son", "Simon-son", "Svide-lius" (compound Swedish and English names, while the first letter "S" is clearly associated with the blades from the "Wilkinson" factory, called "Sword" ~~(sword)~~). Most of the difficulties in finding a name are tied precisely to the system domination of semantic associations and to the equal probability of words surfacing which are similar in sound and morphological structure.

The difficulties just described in remembering surnames are seldom encountered in remembering ordinary words (terms); here the system of semantic associations is strongly dominant over all other associations and pushes aside the phonic and morphological associations of the word. Never does the word "skripka" (violin) evoke the word "skrepka" (paper clip) which is similar in sound, nor does the word "koshka" (cat) evoke the words "kroshka" (crumb) or "kryshka" (cover), nor the word "zdaniye" (building) evoke the phonetically similar word "znaniye" (knowledge).

This fact can be established by means of an objective psychophysiological study, and we will agree with the series of experiments which O.S. Vinogradova and co-workers conducted in our laboratory, and which were published in a special study (A.R. Luria and O.S. Vinogradova, 1959; N. Eisler, 1967 et al).

We know that any painful stimulus causes the blood vessels to contract; cold causes such a reaction. Conversely, heat causes the vessels to expand. In these instances of "specific vascular reactions", a change in the vascular lumen is observed both in peripheral vessels (hands, fingers), as well as in vessels in the head.

In contrast to this, any indifferent but new stimulus (light, sound) causes a "non-specific" or "perception" reaction which is manifested in a contraction of the peripheral vessels (fingers) and expansion of the vessels in the head (E.N. Sokolov, O.S. Vinogradova).

This phenomenon was also used for an objective, psychophysiological analysis of the system of connections which function to form a word (or the system of "semantic fields").

A series of isolated words is suggested to a subject. At first, each word has caused a pronounced "perception" reaction (contraction of the vessels of the hand or expansion of the vessels in the head). However, after using 20-30 different verbal stimuli, this "perception" reaction died away and subsequent words did not provoke any more vascular reactions.

At this moment, the experiment began.

The subject was told that when the signal word appeared whose connection systems we wanted to trace (for example, the word "koshka" (cat)), he must press a key with his right hand; the vascular reactions of the left hand were registered. In another series, he was told that the appearance of the signal word (for example, the word "skripka") (violin) would be accompanied by a painful stimulus. The experiment showed that, in this case, the signal word ("koshka") (cat) concurrent with a motor reaction provoked pronounced "non-specific" or "perception" vascular reactions (the vessels in the hand contracted while the vessels in the head expanded), while the signal word "skripka", accompanied by a painful stimulus -- caused a "specific" painful conditional reaction (contraction of the vessels in the hand and the head).

This fact made it possible to pose the central question: what other words will cause the same kind of reaction, or in other words, which words (similar to the signal word in ~~sense~~ meaning or sound) will cause similar objective reactions indicating that they are in the same system as the signal word?

The experiment using words similar to the signal word in meaning and in sound indicated that only words similar in meaning but not words similar in sound caused an analogous vascular reaction in a normal adult subject; the closer the semantic connection was to the signal word, the more pronounced vascular reaction it caused.

Thus, in the first of these series, the signal word "koshka" (cat) was connected to both a motor and vascular reaction while the word "kotenok" (kitten), "sobaka" (dog), "mysh'" (mouse) caused only a vascular reaction. Words similar in sound such as "kroshka" (crumb), "kryshka" (cover), and "kruzhka" (mug) did not cause any vascular reactions whatsoever (Figure 7).

Fig. 7. Vascular reactions to words similar in meaning ("koshka" (cat) series).

~~A similar thing~~ The same happened in the second of these series: the signal word "skripka" (violin) caused a distinct "specific" vascular reaction (contraction of the vessels in the hand and in the head); the words "smychok" (bow), "struna" (string), "violonchel'" (cello) caused an analogous specific reaction. Words which are farther from the signal words but which are in the same category caused a "non-specific" or "perceptive" reaction (contraction of the vessels in the hands but expansion of the vessels in the head); neutral words such as words similar to the signal word in sound (for example, "skrepka" (paper clip) did not evoke any vascular reactions (Figure 8).

Fig. 8. Vascular reactions to words similar in meaning ("skripka" (violin) series).

This experiment made it possible to isolate for each word a group of words similar in meaning comprising the "semantic nucleus", and a group of words comprising the "semantic periphery", and a group of neutral words which included words similar to the signal word in sound but remote in meaning.

Figure 9 shows statistical computed characteristics of a series of words according to the degree of their semantic similarity to the word "zdaniye" (building).

Fig. 9 Statistically computed vascular indices of the characteristics of a series of words semantically close to the word "zdaniye" (building).

The lower lines are vascular reactions of the hand, and the upper lines -- vascular reactions in the head. The numbers signify the degree of deviation: a number with a "plus" sign is the deviation towards vessel expansion, a number with the "minus" sign -- deviation towards vessel contraction.

We were able to see a completely different picture in children with pronounced mental retardation -- child oligophrenics.

As the experiment showed, in these children it was impossible to observe any distinct predominance of semantic associations, which would be dominant over sound associations. As a rule, in these children, sound associations either hold as much weight as semantic associations or even predominate over them. Therefore, in children with an average degree of mental retardation -- debiles -- both the words "kotenok" (kitten), and "mysh'" (mouse) which are semantically close to the signal word "koshka" (cat), and the words "kroshka" (crumb), "kruchka" (mug), and "kryshka" (cover), which are close to it in sound, caused identical "perception" vascular reactions. In children, with a deep degree of mental retardation, the distortion of the associative system became even more pronounced and words, similar to the signal word in sound, caused the most distinct "perception" vascular reactions while words similar to the signal word in meaning did not cause such reactions (Figure 10).

Fig. 10. Vascular reactions to words similar to the signal word in meaning and in sound in mentally retarded children ("koshka" (cat) series).

It is typical that in children with an average degree of mental retardation -- debiles -- when they are not tired (prior to the beginning of lessons) one can see that words similar to the signal word in meaning caused much more pronounced "~~perception~~" vascular reactions than words similar to the signal word in sound; however, when they are fatigued (after five lessons) the situation changed and words similar to the signal word in sound began to evoke very pronounced "~~perception~~" vascular reactions while words similar to the signal word in meaning ceased to evoke such reactions.

Figure 11 illustrates this situation.

Fig. 11. Vascular reactions to words similar to the signal word in meaning and similar in sound in child oligophrenics when they are rested and when they are tired.

In the cases which have just been described, a disorder in the ~~associative~~ Semantic system which functions to form the lexical meaning of a word, arises as a result of general underdevelopment of the brain or exhaustion causing a drop in the level of their work.

Of considerable interest, however, are cases when a localized lesion of the brain results in a limited pathological condition of the cortex and disrupts the normal matrix of knowledge functioning to form a word. This is shown with particular clarity in lesions of the posterior, parieto-temporal regions of the left hemisphere.

The phenomena, described in these cases, were given the name amnesic-aphasic disorders. Here, the patient who is attempting to remember words (and, primarily, names of objects) began to experience difficulties similar to those which we have observed in a normal person when he is attempting to remember names. Instead of remembering the word "karandash" (pencil), this patient may say "tetrad'" (notebook), "promokashka" (blotter), "mal'chik" (boy), "uchitel'nitsa" (teacher) or even such words which sould like the one needed as "barash", "kondrash" etc.

This phenomena, only recently understood, can be explained by those same laws which we discussed earlier.

As we have already noted, each form of the object potentially evokes a full array of ~~meanings~~ connections, each of which isolates a certain symbol of the object for one of the numerous connections in which the object appears. At the same time, each sought for word evoked a whole group of alternatives associated with it both in content as well as in sound or morphological (structural) similarity. Finding the ~~requisite~~ required word is the choice of such alternatives.

As we have already said, in the normal person, this process of selection is easy because ~~distinguished by the fact that the appearance of the most ordinary or~~ the probability of the appearance of the notion the most adequate meanings dominate, and the probability of their surfacing increases required while the ~~surfacing~~ appearance of the least frequently encountered or least important meanings is ~~pushed aside~~ inhibited and practically becomes nil.

Something quite different occurs in pathology of the cortex. As I.P. Pavlov pointed out, changes in normal ~~strong relationships and perversion of the~~ of the strength "law of force" occur in pathology of the cortex. ~~in which~~ It is well known that in normal subject strong ~~stimuli~~ traces ~~(or tracks)~~ cause strong reactions, while weak stimuli (or ~~tracks~~ traces) cause weak reactions ~~and in which~~ and so the domination of the strong stimuli (tracks traces) becomes much more probable. In a relatively unpronounced pathological (phase) condition of the cortex, they are equalized by a stimulus (track) of varying force (the "equalizing phase"); in the more pronounced phase, weak stimuli (tracks) begin to evoke even stronger reactions than the weak ones (paradoxal phase). This is natural because alternating connections begin to make their appearance with equal probability and dominating connections surface when subsidiary alternates are retarded; in other words, the organized process of selecting the necessary connections becomes impossible.

With a lesion in the parieto-temporal (or parietal-temporal-occipital) areas of the cortex of the left hemisphere (in other words, posterior areas of the speech zone), such a pathological condition affects only the restricted zones in the cortex participating in speech activity, and this is precisely why the patient maintaining complete ability to effect organized selective forms of graphic activity begins to experience pronounced difficulties in remembering names and begins to replace the required words uncontrollably with surfacing supplementary connections which he rejects but which he cannot keep from surfacing.

Sometimes the words surfacing in a patient are similar in thought (so-called verbal paraphasia); sometimes, similar in sound or morphological structure (so-called literal paraphasia). However, impairment of the selective surfacing of the required words is the basic syndrome of such disorders.

When the pathological condition of the cerebral cortex is caused by a focal area located within the parietal-occipital region, this defect is limited to the naming of objects. When temporal zones of the left hemisphere become involved in the focal area, the same phenomena may be observed in comprehending the meaning of words and "paraphasia" then becomes "paragnosia". However, in both cases, there are common physiological mechanisms in the observed defects.

Let us cite several examples of similar disorders which occurred at first in the faulty selection ve coding of the required meanings of words ("paraphasia") and only later became defects in de-coding understanding of the meaning of words ("paragnosia"). A patient who has had an aneurysm in the middle cerebral artery of the left hemisphere removed and whose ~~focal area in the cortex of the~~ left parieto-temporal area of the cortex ~~is limited~~ remains in a pathological state has the following typical difficulties in finding the required words. In re-telling the history of his illness, he says that he had a very bad headache and that he went "into the militia... no, not into the militia...to school...no, not to school...to the Red Army...no, not to the Red Army...well, where people go when they are sick". "To the hospital?" "Oh yes, to the hospital". The patient frequently mixes up words belonging to one category and, instead of "two weeks", he may say "two months...no..."two years"...no..."two hours" ...no..."; instead of "my eyes began to see poorly" he may say: "my head began to see badly" etc. Sometimes, attempts to remember a necessary word results in contamination (fusion) of similar words. To the question: "how did you get sick?" ("kak vy zaboleli?"), he may answer "zabel...zabil...zabel..." etc.

Serious disorders in selectivity are revealed in the meaning of objects. He calls "lokot'" (elbow); "ukho" (ear)... ~~(ruka)~~ (hand)...ruka... logot'...lob... (forehead) lobot' (contamination of "lokot'" and "lob") ~~(forehead)~~..."; "plecho" (shoulder) -- "pech'" (dough)...pecho..."; "resnitsy" (eyelashes) -- "shche...shcheki... vektsy...no...vitsy..." (he confuses "veki" (eyelids) and "resnitsy" (eyelashes)) and, after he has said the first syllable -- "re..." he says "remni...red'ki...veki...reztsy...". He has difficulty in naming a "trolleybus" (trolley bus) and searches for the syllable in succession "samo...no, not samolet (airplane)...avtobus (motor bus)... ko...kro...electric tovlebus...korolebus...akrobolyus...revolyutsiya... no...aktobus...aprobus..." etc.

The disorder in selecting the required sound complexes occurs in such a patient even when he is repeating comparatively simple words. Thus, the patient repeats the word "okno" as "tokom" (a shifting of sounds) -- "kamno...dom...kolno...kino...sekno (from "steklo"), kopno...stekno...zhelezo...no...okno!" After he has repeated the word "les" (forest) well, he unsuccessfully attempts to repeat the word "belka" (squirrel), pronouncing "les...leska...no...gidka...ryzhaya lisa...beska...belka!" After repeating the word "poyezd" (train), he searches as follows: "polez...polos...samolet (airplane)...no... poles..." etc.

The patient has considerable difficulty when he tries to pronounce <u>pairs of words</u>; in these instances, the number of competing alternatives includes both traces of words just pronounced and difficulties in selecting required words. Thus, after repeating the pair "dom-les" (house-forest) he unsuccessfully attempts to repeat a second pair of words -- "noch'-igla" (night-needle): "noch'...and les...no...zhelak ...igla...and...zemlya"; attempts to repeat the pair "skaf-truba" (closet-pipe) lead to such attempts as: "shaf...and here...idet kvarkhu...pila...no...trub and shofen...shofa...shofer...shofar..." etc. The pair "volk-pila" (wolf-saw) is repeated as "...lolk...volk... and vila...a tree is cut down with what...pilka..." etc.

It is quite typical that the described defects in selective surfacing of required words occur only in spontaneous speech, in the naming of objects, and, to some extent, in repeating words (especially if these words are complicated, rarely encountered, or if they conflict with alternative connections). They do not appear at all in the pronunciation of an ordinary series (for example -- one, two, three, four etc), and they occur only in a patient when there are competing alternatives (for example, in naming months in reverse order: "yanvar' (January)...devyatyr'...deryab...dekabr' (December), oktyabr' (October)" etc).

It is significant that singing very simplified tunes does not cause even the slightest difficulty to the patient.

These facts indicate that the selective re-production of words encounters an obstacle here in the uncontrolled surfacing of a whole array of alternatives, some of which are connected with the sought for word by meaning, some by sound or by morphological structure; and they indicate that these alternatives surface with equal probability and result in a noticeable disorder in the selection of the required word sometimes causing extraneous words (paraphasia) and sometimes -- a fusion of words (contamination) while the prosodic scheme of words is usually maintained.

A study of paraphasias, occurring in these instances, is of undoubted interest to linguists in revealing the hidden complex connections of a word which remain invisible in the normal person but which is very pronounced in pathological conditions.

Losses in the selectivity of verbal connections, similar to the phenomena described here, may reveal themselves in the sensory sphere -- or to be more exact, in understanding the meaning of words.

This is very pronounced when the focal area of the lesion affects the left temporal region. If it is located in the posterior third of the upper temporal gyrus of the left hemisphere, phonological hearing disorders and "alienation of word sense" phenomena, which were described above, become a part of the clinical picture. If the lesion is located near this zone, it also has a "perifocal" nature -- the same disorders may take on a similar but even more interesting form. The patient does not manifest severe signs of dissociation of the sound structure of words, but the meaning of heard words (especially if these words are rather rarely encountered) loses its precise nature. However, he begins to perceive in a distorted fashion the meaning of words relating them to another sphere and falsely semanticizes their meaning. In some cases, the word "gusenitsa" (caterpillar) is understood as "gusynya" (goose), the word "zausenitsa" (hangnail) as "something which is found behind the mustache", something like "podusnikov" (whiskers), the word "mokritsa" (wood-louse), as "mokraya pogoda" (rainy weather) etc.

Attentive study of false semantization of the meaning of words again goes back to that already mentioned fact of a disorder in selectivity and may be of considerable interest in analyzing the potential sense associations of a word, which are latent in a normal person and which are revealed in cerebral pathological conditions.

Neurolinguistic Analysis of the Logical-Grammatical Structure of Speech

After this neurological analysis of the phonic structure and lexical composition of speech, let us now turn to the neurolinguistic analysis of the logical-grammatical structure of speech.

Classification of the basic logical-grammatical structures of a language has always belonged to the most important and voluminous chapters of linguistics, but also most incomplete chapters.

Study of the paratactic and hypotactic structure of the preposition was very advanced even at the end of the last century, and the basis of a scientific syntax, to which such researchers as F.I. Buslayev (1868-69), A.A. Potebnya (1888), A.A. Shakhmatov (1920), A.L. Peshkovsky (1922) et al made an important contribution, had already been established. For a long time, this study limited itself to linguistic descriptions and historical-linguistic research and, it was only within the last few years, that a tremendous push was given to the subject in the form of studies of structural linguistics and, in particular, in an analysis of the logical-grammatical structures of syntax (N. Khomskiy, 1957).

However, one aspect of the study of the basic logical-grammatical forms of a language remained incomplete: the relationship between form (morphology) and content (semantics) of language, in which the problems of structural linguistics are closely interwoven with the problems of speech psychology was not made sufficiently clear.

It is known that the same grammatical forms (for example, forms expressed by the same cases or prepositional constructions) expressed relationships, which vary greatly in content, and whose origin sometimes dates back to widely different historical periods. Thus, constructions of the genitive case may designate a part of the whole (the partitive genitive: a piece of bread) or it may represent a much more complicated structure (attributive genitive: the brother of the father); constructions using the preposition "ot" (from) may have a spatial("Ya idu ot doma -- I leave the house) or a causative meaning (eta bolezn' ot prostudy -- this illness is due to a cold). How can these forms be classified rationally? What are the underlying factors and what are the different mechanisms used in their formation?

Neurolinguistic studies may be of essential importance in answering this question.

Already at the end of the last century, the young Swedish linguist Svedelius (1897) expressed the opinion that all types of communications can be divided into two large groups with a profoundly different psychological nature. In the first group, which he called "~~procedural~~ communications", language only fixes certain events which can be expressed by visual extra-linguistic means; "the little girl is crying" is an example of this construction. In the other group, linguistic means play a very special role ~~peculiar to~~ language; they express well known relationships by abstracting well known signs and isolating the abstract relationships based on them which cannot be expressed by visual extra-linguistic means. Svedelius called this class "communications of relations" group. "Socrates is a man" is an example of this group.

Are both these classes radically different constructions? Are they based on different psychological mechanisms and are they arrived at by different cerebral mechanisms?

Neurolinguistic studies, conducted over the course of a long time (see ~~G.~~ Head, 1928; A.R. Luria, 1943, 1947, 1962 et al), have made it possible to take an important step towards answering this question. Observations have shown that whereas processes of visual thought, only expressed in the form of speech, form the basis for "~~procedural~~ communications", "communications of relations" involve operations of spatial coordination, uniting the correlative elements of a whole sentence into a single simultaneous (quasi-spatial) structure. Such components of simultaneous spatial relationships can easily be seen in the process of understanding such comparative constructions as "a circle under~~neath~~ a square", "spring comes before winter", or "summer comes before fall", or "~~Olga~~ is lighter than ~~Sonya~~ but darker than ~~Katya~~"; they can also be detected in a whole series of constructions in which cases become representations of well-known reciprocal relationships: a typical example may be found in the distinction between two such quasi "symmetrical" constructions as "the brother's ~~of the~~ father" and "the father's ~~of the~~ brother", "the master's ~~of the~~ dog" and "the dog's ~~of the~~ master".

The basic ~~inner~~ psychological difference, between the two constructions, ~~which is very pronounced in psychology~~, is confirmed by these neurolinguistic studies.

Experience shows that a lesion in the parietal-occipital regions of the left hemisphere, which is the cortical apparatus for spatial analysis and synthesis, provokes a syndrome which is very important for neurolinguistics. Patients with a lesion in these areas of the brain frequently lose their sense of orientation in space: they confuse right and left, they are unable analyze the positions of the hands of a watch ~~to move in a clock-like direction~~, and they cannot read a geographic map, mixing up East and West. They are incapable of constructing figures in three-dimensions by correctly assembling their elements, and they begin to have marked ~~inordinate~~ difficulties in arithmetic, not knowing how they should put the numbers when using them for arithmetical operations involving inner schemes ~~mental arithmetic (tables)~~; the decimal system of numbers breaks down completely ~~for them~~, and they are unable to execute operations with number categories passing with the required ease from one category to another.

A typical peculiarity of these patients is the fact that with them, ~~the~~ different logical-grammatical constructions, which are different by their internal nature, do not suffer the same fate. As a rule, whereas "~~procedural~~ communications of events" can remain intact, the "communication of relations" breaks down ~~in them~~, and the patient loses his ability to make use of them.

This can be easily ascertained by giving to the patient grammatical ~~speech~~ constructions which are similar in form but different in their psychological structure. The construction "the little girl is crying" remains comprehensible ~~to them~~, whereas they begin to have quite a bit of difficulty in understanding ~~the~~ such construction as "Socrates is a man". The construction "a piece of bread" remains comprehensible ~~to them~~, but the construction "the brother of the father" is not understood at all and "symmetrical" constructions such as "brother of the father" and "father of the brother" seem to them to ~~be~~ have the same meaning. Constructions with complicated spatial meanings of prepositions such as "spring comes before summer", "summer comes after spring" or "the circle under~~neath~~ the square" or "the square under~~neath~~ the circle" are incomprehensible while constructions in which the prepositions do not express these spatial relationships ("this illness ~~is due to~~ comes from a cold") continue to be comprehended quite easily.

The importance of neurolinguistic analysis, which parses factors making up the different constructions, can easily be verified if such patients are traced to see with what ease they assimilate "~~procedural~~ communication of events" and at what point it is difficult for them to understand a "communication of relation" comprising the same number of words.

Let us discuss only one example showing how such precise data can be obtained by observing disorders in understanding logical-grammatical constructions in patients suffering from a lesion in the parieto-occipital regions of the left hemisphere.

A patient with a bullet wound in the parieto-occipital regions of the left hemisphere manifested pronounced defects in writing, reading, and understanding speech. ~~during the first period while the bullet remained in symmetrical regions of the right hemisphere; these defects reversed themselves, but the~~ This inability to immediately understand the ~~thought of~~ complex logical-grammatical relationships remained and it was difficult for him to find necessary words (of the type which we described earlier). We followed the patient for twenty-six years as he repeatedly came to our clinic.

The patient was able to understand simple sentences of the "communication of event" type ("the snow is falling on the street", "the little boy became ill and a doctor came") without any difficulty whatsoever, and he was also able to understand the sense of even such longer sentences as "the father and mother went to the theater, and the old nurse stayed at home with the children".

However, the patient remained incapable of having an immediate understanding of the logical grammatical structures, mentioned above, which express "communication of relations" (such as "the brother's father", and "the father's brother", "the circle under the square", and "the square under the circle", "a fly is larger than an elephant" or reverse, "spring comes before summer" or reverse), and pointed out each time: "I understand each one when it is separate but never when they are together"!". Even after prolonged rehabilitative re-training, he was still unable to grasp immediately complex logical-grammatical structures, and the patient was forced to make use of a long chain of consecutive reasonings in order to reach a conclusion about the meaning of this construction. We would also like to show a comparison of how the patient understood both types of speech construction just mentioned.

> The patient is read an excerpt: "Buratino saw how a thick head with a long nose appeared out of the cellar and then a large gray animal on his short feet came out, sniffed the air and, seeing there was nothing to eat, slowly went away".
>
> The patient translates the excerpt: "Well...Buratino was standing there, and out of the cellar came some kind of an animal with a long nose...it sniffed the air, saw that there was nothing to eat, and went away". Is it difficult? No, it is not difficult..."

He is given another excerpt: "Tall trees of a rare variety bearing large fruit hidden under the leaves and cones, similar to fruit ~~cones~~ grew on the right and left of the house. Everywhere hung Little lanterns, ~~hung everywhere~~ made of colored paper in the form of gay little faces with a mouth and ears, which were reflected in the pond on which four white swans swam, were hung everywhere".

The patient has difficulty in retelling the story: "No...I don't catch everything...there was something about...well this... now...it is difficult to say...it was about lanterns...and about swans in a pond...and on the left and right...not unlike the forest ...a swan...and lanterns...".

The story is read for the second time.

"Well there...on the left and the right...there were these... trees...and fruit...and even lanterns...and swimming swans".

The story is read for the third time.

"Well there they said that there was a house...and near this house were some fruit trees...they looked like spruce cones...and there was also...lanterns...and there was a pond...and floating swans...".

The story is read a fourth time.

"Trees were on the left and on the right of a house...with large fruit...and everywhere there were lanterns...and near them were little faces...no...lanterns...and between the lanterns hung colored paper...no...I don't understand".

It is easy to see that the patient could not understand the second excerpt which expresses verbally a whole series of relationships of inter-subordinate objects, and all the information given him resembled ~~borken~~ broken up fragments which the patient could not explain.

It is quite understandable that impairment in ~~synthesizing~~ relation individual elements of a logical-grammatical structure into a single whole, which was observed in the patient, remains the basic obstacle for understanding those complicated "communications of relations", which a normal adult would be able to understand without difficulty.

All these findings are of primary importance for linguistics. They make it possible to define a special factor which lies at the basis of complicated forms of logical-grammatical ~~speech~~ structures and which conditions those types of grammatical structures which R. Jakobson calls 'operations of reconciling linguistic formations on the basis of a simultaneous (selective) organization'.

There is no doubt that neurolinguistic analysis renders possible a new classification of logical-grammatical structures which will be based on the identification of physiological factors ensuring the simultaneous factors necessary for complex linguistic correlation.

Neurolinguistic Analysis of the fluent speech and (Propositionizing) ~~Coherent Statement~~

Heretofore, we have considered only the way in which neurolinguistic analysis contributes to the study of logical-grammatical structures of speech. Now we must concern ourselves with what has become known about the mechanisms of the fluent speech ~~as propositi~~ coherent statement through neurolinguistic studies.

As we mentioned earlier, Jackson (1866) had already pointed out that the "propositionizing" ~~coherent statement~~ is the unit of speech; then followed the conversion of speech into a linguistic statement passing through the stage of internal speech just as the conversion of heard speech into comprehension of the thought became one of the basic problems of psycholinguistics.

him resembled ~~berken~~ broken up fragments which the patient could not explain.

It is quite understandable that impairment in ~~synthesizing~~ relation individual elements of a logical-grammatical structure into a single whole, which was observed in the patient, remains the basic obstacle for understanding those complicated "communications of relations", which a normal adult would be able to understand without difficulty.

All these findings are of primary importance for linguistics. They make it possible to define a special factor which lies at the basis of complicated forms of logical-grammatical ~~speech~~ structures and which conditions those types of grammatical structures which R. Jakobson calls 'operations of reconciling linguistic formations on the basis of a simultaneous (selective) organization'.

There is no doubt that neurolinguistic analysis renders possible a new classification of logical-grammatical structures which will be based on the identification of physiological factors ensuring the simultaneous factors necessary for complex linguistic correlation.

Neurolinguistic Analysis of the fluent speech and (propositionizing) ~~Coherent Statement~~

Heretofore, we have considered only the way in which neurolinguistic analysis contributes to the study of logical-grammatical structures of speech. Now we must concern ourselves with what has become known about the mechanisms of the fluent speech ~~as proposit~~ coherent statement through neurolinguistic studies.

As we mentioned earlier, Jackson (1866) had already pointed out that the "propositionizing" ~~coherent statement~~ is the unit of speech; then followed the conversion of speech into a linguistic statement passing through the stage of internal speech just as the conversion of heard speech into comprehension of the thought became one of the basic problems of psycholinguistics.

Has neurolinguistic analysis anything to say about the mechanisms of this process?

Among all the forms of speech disorders which accompany localized lesions of the brain, we can isolate two which could give us important information on this topic.

In the forms of speech disorder, just examined, which accompany lesions in the parieto-occipital regions of the left hemisphere and which are responsible for so-called "semantic aphasia", we have already encountered the case where the essential condition for decoding a complicated statement and transforming it into a simultaneous logical pattern has been destroyed.

The reverse obtains when the lesion is located in the ~~post~~ [posterior parts of the lower] -frontal areas of the left hemisphere closely connected with the temporal region by means of connective paths. In these cases, the process of decoding the perceived speech is maintained without apparent difficulty but the process of converting thought into coherent speech -- in other words, the process of coding the statement -- suffers considerably.

Patients with this form of speech disorder, which we have called "dynamic" aphasia" (A.R. Luria, 1947, 1962, 1963) [A.R. Luria & L.S. Tsvetkova, 1967], retain the ability to understand speech ~~directed towards them~~ and do not have any difficulty in ~~assimilating~~ [decode] the above mentioned logical-grammatical structures; they are able to name objects without any difficulty and they can repeat a sentence spoken to them. The pronounced difficulty comes when the patients are confronted with the problem of expressing some thought in words and of making a statement however little developed. In these cases, patients with a severe form of this ~~illness~~ [defect] cannot pronounce a single word; patients with a less pronounced form begin to experience great difficulty and either they say they cannot give coherent form to the scraps of thoughts in their heads or they replace the expected statement with some simplified oral stereotypes. Thus, one of these patients who had been asked to say something about the North, -- after a prolonged pause said: "there are bears in the North" -- and when asked to develop this theme in a coherent statement said after a prolonged interval: "and I bring this fact to your attention...".

The difficulties of making a coherent statement, observed in "dynamic aphasia", have long been hard to explain and even now remain, to a great extent, enigmatic. It is only in recent years that facts have been received which make it possible to throw some light on the mechanisms involved.

Observations made in recent years by L.S. Tsvetkova (1966) showed that, with these patients, not all elements of the statement are affected to the same degree. Experiments have made it possible to establish that the nominative function of speech remains intact in these cases while the predicative is deeply affected. This was shown ~~even~~ in Special experiments in which such patients had to repeat, within a short period of time (one minute), the names of objects (nouns) and statements of actions (verbs): it turned out that the latter was much more difficult and, during this time, they were able to repeat four or five times fewer verbs than nouns.

These observations therefore suggest that a lesion in the frontotemporal regions (front areas of the speech zone) caused a disturbance in the predicative function of speech which, as L.S. Vygotskiy demonstrated in his day, is an important link in converting thought into an oral statement.

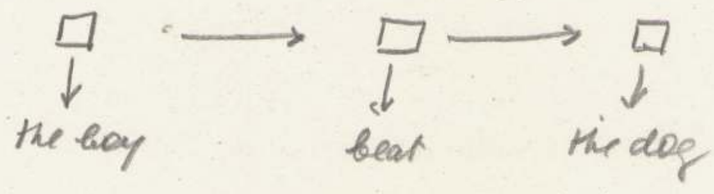
This hypothesis compels us to approach closer to an analysis of precisely which links in the process of converting thought to coherent speech suffer the most in these cases, and wherein precisely lies the difficulty lying at the basis of coherent fluent speech.

The hypothesis that the main difficulty is the absence or vagueness of the theme of the statement was immediately rejected: this group of patients had the same difficulties when the theme of the statement was conveyed to them in speech form or when they were asked to describe in coherent speech a picture put in front of them. Finding the appropriate names was not the greatest difficulty because these patients were able to easily name each indicated object. No difficulties in motor pronunciation of words was observed in these patients, and the ~~moterial~~ "output" of speech in single words remained intact.

It would be supposed that, in this case, the disorder would be situated in the transfer link from thought to speech, in other words, -- that the formation of the "linear ~~pattern~~ scheme of a sentence" is disrupted ~~here~~, the formation of which is an important stage ~~following the appearance of~~ formed by the link of internal speech which is ~~summary~~ abbreviated by its structure and which is predicative by its function (L.S. Vygotskiy, 1934).

This hypothesis made us believe that if a disintegrated linear pattern of a sentence could be successfully replaced by some external supports, which by themselves bore no particular content but which would designate the main links of the broken chain, the defect in the coherent speech would, to a certain extent, be overcome.

This hypothesis was checked and confirmed in a series of observations published earlier (A.R. Luria, 1948, 1963) and in some special experiments conducted by L.S. Tsvetkova ~~(unpublished)~~ (A.R. Luria & L.S. Tsvetkova, 1967). As the facts showed, if a series of three blank cards which showed the linear pattern of a sentence were spread out in front of a patient who was unable to make even a simple coherent statement (for example, "the ~~little~~ boy beat the dog"), the



about the regulatory or pragmatic aspect of speech.

Linguistics, which has studied in detail the phonetic, morphological, grammatical, and syntactic aspects of language, has paid little attention to the role which language plays not only in the transmittal of information but in its effect on the man who perceives speech and, in the final analysis, on the speaker himself.

The question of the ~~signalling or~~ regulating function of speech was raised by physiologists, particularly I.P. Pavlov, in his account of the two signal systems of operation, and by psychologists, especially L.S. Vygotskiy (1934, 1956, 1960) who based an entire system of scientific psychology on his concept of the decisive influence of speech on the formation of psychic processes. Skinner (1957) has also dealt with the pragmatic function of speech in a special study devoted to the theoretical analysis of speech as a means of influencing the behavior of an individual. Linguistic studies have regarded the pragmatic function of speech only in isolated cases.

The role of speech in regulating behavior was the object of study in our laboratory over the course of many years, and the results of these studies have been made known in a number of publications (A.R. Luria, 1956, 1958, 1959, 1961). These studies showed that, during the course of a child's development, speech does not immediately acquire the regulating importance which it has in an adult. Research has also made it possible to describe the main stages in the formation of the regulating function of speech beginning with the period when, addressed to a small child, speech may induce specific action but cannot ~~check~~ block an act once begun nor create the basis for complicated programming of behavior and ending with that period when the function of determining and regulating behavior begins to be assured by explicit speech, and later by internal speech.

All this research has left an important question unanswered: what are the neurological mechanisms which ensure the regulatory function of speech, and whether the cerebral mechanisms which effect this function are the same as those which ensure the formation of phonetic, nominative, and logical-grammatical structures of the speech process. These questions have been the subject of neuropsychological study by the author and by his laboratory over the past few decades. These studies, some of which have been published (A.R. Luria, 1962, 1966, 1969 A.R. Luria and E.D. Homskaya, 1964, 1966) and some of which are the object of continuing research, have led to important results.

As these studies have shown, lesions in the classical "speech zone" of the left hemisphere, resulting in disorders in phonological hearing and "motor" patterns of speech, or to defects in decoding complicated logical-grammatical structures, still do not cause disorders in the regulatory function of speech. Patients suffering from all the enumerated lesions do not lose the ability to obey verbal instructions given to them (of course, to the extent to which they understand them), nor the ability to control their own activities. It is precisely because of this that a systematic rehabilitative re-education can, to some extent, compensate for their deficiences (A.R. Luria, 1948).

However, quite another picture is seen in patients with lesions in the frontal (pre-frontal) areas of the brain.

Patients in this group completely preserve both their phonological hearing, which enables them to perceive words distinctly, and the ability to assimilate the meaning of complicated logical-grammatical construction. As a rule, they do not have any difficulties whatsoever in expressing themselves, they can name objects, repeat sentences, relate the contents of a story, and can even make complicated statements (in the latter case, these patients may show only some disorder in selecting what they will say, and accessory associations may crop up).

In these patients substantive disorders may appear only in the <u>regulatory</u> function of speech.

When there are serious lesions of both frontal lobes, even the simplest verbal instructions fail to elicit the desired ~~response~~ action. Easily understanding and retaining the instruction "raise your hand" or its more complicated form -- "when you hear a knock, you will raise your hand", such patients will perform the required motions only once or twice and, after several attempts, they will react to the given signal with an echoed reproduction of the verbal instruction: "yes, yes, when you hear a knock, you must raise your hands", but they make no move to perform this gesture. Patients with less serious lesions in the frontal lobes can for a period ~~assimilate~~ fulfill a more complicated instruction without any difficulty, for example: "when you hear one knock, you will raise your right hand and when you hear two knocks, you will raise your left hand", but this instruction ~~also~~ easily loses its regulatory importance, and the patient (although he retains it well in memory and can repeat it without difficulty) begins alternatively to raise one hand and then the other one regardless of the nature of the signal given, ~~or he~~ and They replaces the selective reaction with the appropriate hand by raising them both in a stereotyped gesture. This defect is particularly pronounced when the immediate effect of a situation comes into conflict with the conditioned meaning attributed to it by speech: thus, if such patients are asked to raise a fist in response to a raised finger, they retain the verbal instruction ~~and~~ but begin to adapt their own movement to the stimulus and to reproduce immediately, by echopraxia, the gesture of the fist or the finger perceived by them.

In all these instances, speech in retaining its phonetic, lexical, and grammatical structure, loses its signalling or its regulatory function, and the high level of organization of psychic processes, at which the "second system of signalization" plays a decisive role, breaks down.

We cannot indicate, with sufficient decision, the physiological mechanisms forming the basis for the break-down of this signalling or regulatory function of speech. However, these facts which denote a possible dissociation of the basic functions of speech and the role which the frontal lobes of the brain play in ensuring the regulatory function of speech, may play an essential part in explaining certain phenomena important to linguistics.

Conclusion

We have shed some light on certain facts obtained in contemporary neurolinguistic studies and we have outlined those problems which obtain in a description of them.

The field of neurolinguistic studies presents tremendous difficulties since the skilled assembly of pertinent facts requires the recording, to an equal degree, of neurological, psychophysiological, and linguistic ~~data.~~ knowledge.

Work in this field, preparation for which has gone on for over a century, has really only just begun. However, even the little that has been done has made it possible to describe observations made in the last few decades and gives rise to our belief that a new series of facts, equally important to neurology and psychology as well as to linguistics will become accessible to science.

Broadbent D.E. (1958). Perception and Communication. Pergamon Press, London, 1958.

Broca P. (1861). Remarques sur le siege de la faculte du language articule. Bull.Soc.Antropol., Paris, 6, 1861.

Brown R. (1958). Words and Things. The Free Press. Glencoe.

Buehler K. (1943). Sprachtheorie. Jena, Fischer.

Chomsky N. (1957). Syntactic structures. Mouton, s'Growenhage.

Head H. (1926). Aphasia and kindred disorders of speech. Cambridge I-II.

Isserlin M. (1929-1932). Die Pathologische Physiologie d. Sprache. Ergebnisse d. Physiol., 29, 33, 34.

Jackson H. (1866). Notes on the Physiology of Language. In: Selective Writings. vol.II. Basic Books. N.Y., 1958, 121-128.

Jackson H. (1878). On the affections of speech from disease of the Brain. In: Selective Writings. Basic Books, N.Y., 1958, p.154-204.

Jakobson R. and Halle M. (1956). Fundamentals of language. Hague, Mouton.

Jakobson R. (1964). Towards a linguistic typology of aphasic disorders. In: "Disorders of Language". Ciba Foundation Symposium. Churchill, London.

Lotmar F. (1935). Zur Pathophysiologie der erschwerter Wortfindung bei Aphasischer. Schweiz. Arch. fur Neur. u. Psychiatr. 15.

Luria A.R. (1959). The directive role of speech in development and dissolution. "Word", N.Y., vol.15, p.341-352, 453-466.

Luria A.R. (1961). The role of speech in regulation of normal and abnormal behaviour, London, Pergamon Press.

Luria A.R. (1964). Factors and Forms of Aphasia. In: Disorders of Language. CIBA Foundation Symposium. Churchill, London.

Luria A.R. (1966). The regulatory function of speech in development and dissolution. In: Conference on Verbal behaviour. N.Y. 1965 (in print).

Luria A.R. and Homskaya E.D. (1963). Le trouble du role regulateur du language au cours des lesions du lobe frontal. Neuropsychologia. I. p.l. 9-26. (x)

Miller G. (1951). Language and Communication. McGraw-Hill. N.Y. Ombredane (1951) L'aphasie et l'elaboration de ** la pensee explicite. Paris. Presse Universitaire.

Skinner B.F. (1957). Verbal behavior. Appleton-Century. N.Y.

Svedelius C. (1897). L'analyse du language. Uppsala.

Troubezkoi N. (1939). Grundriss d. Phonologie. Prag.

Vinogradova O.S. and Heissler N.A. (1967). Comment l'enregistrement des reactions Vasculaires peut mettre en evidence des systemes d'associations verbales, L'enfance, No. 5.

*Luria A.R. and Vinogradova O.S. (1959). An objective investigation of the dynamics of semantic systems. Brit.Journ. Psych. Vol.50, p. 89-105.

**Pick A. (1913). Die agrammatische sprachstorungen. Berlin, Springer.

(x) Luria A.R. u Tsvetkova L.S. (196). Towards the mechanisms of „dynamic aphasia". Foundations of Language.

Blinkov, S. M. (1955) Особенности строения большого мозга человека [The Nature of the Human Cerebrum], Медгиз.

Boskis, R. M., and Levina, R. Ye. (1936) "One of the Forms of Acoustic Agnosis," Невропатология и психиатрия [Neuropathology and Psychiatry], No. 5.

Buslayev, F. I. (1858) Опыт истроической грамматики русского языка [The Historical Grammar of the Russian Language], Saint Petersburg.

Vygotskiy, L. S. (1934) Мышление и речь [Thinking and Speech], Moscow, Соцэкгиз.

----- (1956) Избранные психологические исследования [Selected Psychological Studies], Moscow, Publishing House of the Academy of Pedagogical Sciences.

----- (1960) Развитие высших психических функций [Development of the Higher Psychic Functions], Moscow, Publishing House of the Academy of Pedagogical Sciences, RSFSR.

Kabelyanskaya, L. G. (1957) "Condition of the Auditory Analyzer in Sensory Aphasia," Журн.неворпатол.и псих. им.Корсакова [Korsakoff Journal of Neuropathology and Psychiatry], Vol. 57, No. 6.

Kozhevnikov, V. A., Chistovich, L. A. (1965) Речь. Артикуляция и восприятие. [Speech. Articulation and Perception].

Levina, R. Ye. (1940) Недостатки чтения и письма у детей [Reading and Writing Deficiencies in Children], Учпедгиз.

Luria, A. R. (1946) "Pathology of Grammatical Operations," Известия Акад. пед. наук РСФСР [News of the Academy of Pedagogical Sciences, RSFSR], No. 3.

----- (1947) Травматическая афазия [Traumatic Aphasia], Moscow, Publishing House of Academy of Medical Sciences, USSR (English edition, ~~1967)~~. Mouton & Cie, The Hague, 1970

----- (1948) Восстановление функций мозга после военной травмы [Restoration of the Brain's Function After Combat-Induced Trauma], Moscow, Publishing House of the Academy of Medical Sciences, USSR (English edition, ~~1963)~~. London, Pergamon Press, 1963

----- (1956, 1958) Проблемы высшей нервной деятельности нормального и аномального ребенка [Problems of Higher Nervous Activity in a Normal and Abnormal Child], Vols. I and II, Moscow, Publishing House of the Academy of Pedagogical Sciences, RSFSR.

----- (1962) Высшие корковые функции человека [Higher Cortical Functions of Man], Moscow, Moscow University Publishing House, (English edition, ~~No. 4, 1965]~~. New York, Basic Books, 1966]

----- (1963) Мозг человека и психические процессы [The Human Brain and ~~Its~~ Psych~~ic~~ological Processes], Moscow, Publishing House of the Academy of Pedagogical Sciences, RSFSR (English edition~~, No. 4, 1966)~~. New York Harper & Row, 1966

Luriya, A. R., and Khomskaya, Ye. D. (Ed.) (Homskaya) (1966) Лобные доли и регуляция психич. процессов [Frontal Lobes and Regulation of ~~Psychic~~ Psychological Processes], Moscow, Moscow University Publishing House.

Nazarova, L. K. (1952) "The Role of Speech Kinesthesia in Writing," Советская педагогика [Soviet Pedagogy], No. 6.

Pavlov, L. P. (1949) "Lecture on the Function of the Large Hemispheres of the Brain," Полн. собр. соч. [Complete Collected Works], Vol. IV, Publishing House of Academy of Sciences, USSR.

Peshkovskiy, A. A. (1922) Русский синтаксис в научном освещении [Russian Syntax in Scientific Exposition], Moscow.

Potebnya, A. A. (1888) Из записок по русской грамматике [Notes on Russian Grammar], Vols. I and II, Khar'kov.

Sirotkin, M. M. (1949) Опыт восстановительного обучения при афазии [Experience in Re-training in Aphasia], Candidate's dissertation, Moscow.

Tsvetkova, L. S. (1966) Исследование нарушения предикативной функции речи при динамической афазии [A Study of the Disorder of the Predicative Function of Speech in Dynamic Aphasia], (in print).

----- (1966) Нарушение схемы активного высказывания [Disruption of the Pattern of Active Expression].

Shakhmatov, A. A. (1921) Синтаксис русского языка [Syntax of the Russian Language], Moscow-Leningrad, Publishing House of the Academy of Sciences