Proc. Nat. Acad. Sci. USA
Vol. 70, No. 4, pp. 1278–1283, April 1973

Neuropsychological Studies in the USSR. A Review (Part II)

A. R. LURIA

Department of Neuropsychology, Psychology Faculty, Moscow University, Moscow, USSR

Neuropsychology of activation and attention

With a neuropsychological analysis of speech processes we come close to one of the most important problems of modern psychological science—that of the mechanisms of the higher forms of activation and attention.

After the classical works of Moruzzi and of Magoun, Jasper, and Lindsley, the basic mechanisms of arousal evoked by the brain-stem ascending reticular formation were analyzed. Nevertheless one important problem remained unsolved. What are the mechanisms providing a cortical regulation of these mechanisms, and which cortical areas play a leading part in *descending influences*, which are of basic importance for the processes of higher forms of attention? These problems started with the studies already mentioned, and they were discussed in detail in a series of works by Hernandes Péon and his collaborators.

Neuropsychological studies of the last decade tried to give some answers to these questions. As was shown in the studies already mentioned, descending fibers that constitute the basic mechanisms of the cortical influences to the brain stem start from all parts of the cortex, but predominantly from the *frontal* cortical zones. That assumption was proven by physiological studies that showed that every state of expectancy evokes specific contingent negative waves (or "expectancy waves"), which start in the frontal parts of the brain and which are expanded to the other parts of the cortex (86). It was known, as well, that every active state of attention or mental work results in the appearance of synchronously working foci of excitation, which stop after the active state of the cortex is eliminated (87, 88).

A careful neuropsychological analysis of these problems and of the mechanisms underlying a derangement of active attention was made by E. D. Homskaya and her coworkers (89–92, 100–101, 104–105, 111–112). These studies used different methods as indicators of arousal process; the methods included recording changes in the frequency of the EEG rhythms, analysis of relations of ascending and descending parts of the alpha wave, evoked potentials, galvanic skin reflexes, changes in the plethysmogram, etc. The technique used in the studies was elaborated by the investigations of the orienting reflexes by E. N. Sokolov and his coworkers (93–99). These investigations showed that every mobilization of attention evoked very clear objective symptoms: constriction of the vessels of the finger and dilatation of the vessels of the head, changes of the spectrum of EEG, etc. E. D. Homskaya was able to make an approach to the brain mechanisms for regulation of the activation processes and to show which parts of the brain cortex are responsible for this regulation.

These studies showed that every verbal instruction that mobilizes the attention process (an instruction to count the number of stimuli, to analyze changes in their intensity, etc.) evokes in normal subjects a clear shift of the frequency of EEG waves towards higher frequencies; the same results were observed in patients with lesions of the posterior parts of the brain. However, in patients with lesions of the anterior parts of the brain (and especially lesions of the mesial and basal parts of the frontal cortex), such changes could not be evoked or the changes mentioned remained unstable. In some patients even paradoxal reactions were observed, and attempts to mobilize the attention resulted in appearance of pathological slow waves (91, 100, 101).

Similar data were obtained in experiments where a new indicator of vigilance was used. In studying the changes in the relations of the ascending and descending fronts of the alpha rhythms, A. A. Genkin (10, 103) showed that in quiet states a periodical change of these relations with a frequency of 7–8 sec was observed and that any arousal of attention (intellectual activity, computation, etc.) resulted in a breakdown of such periodical changes. E. D. Homskaya and her coworkers showed that similar data were obtained in patients with lesions of the posterior parts of the brain; but no such changes were observed in patients with lesions of the frontal lobes (91, 104, 105).

It was shown further that, in normal adults (106), verbal instruction that mobilizes attention results in an amplification of evoked potentials of the appropriate parts of the cortex and that these changes preserve their highly specific type according to the modality of attention; these changes increased with age in studies of children (107, 110). Neuropsychological studies showed that, in lesions of the posterior parts of the brain, this amplification of evoked potentials after verbal instruction was preserved, but no such changes were seen in patients with lesions of the frontal parts of the brain (91, 111, 112). Very similar data were obtained by a polygraphic study with simultaneous recording of EEG, pulse rate, plethysmographic reactions, etc. While in patients with lesions of the posterior parts of the brain some pathological changes of the background could be observed, verbal instruction resulted in elimination of these pathological changes and even in compensation of the defects observed. A different picture was seen in patients with lesions of the frontal lobes of the brain. In these patients, verbal instruction did not result in any changes of the EEG waves or of the vascular processes (113, 114).

All these studies have a very high neuropsychological significance: they show that *the frontal lobes of the brain (and especially their mesial and basal parts) play a considerable role in regulation of the highest forms of attention, evoked by means of verbal instruction.*

Neuropsychology of conscious activity

All data I mentioned lead us directly to the central problem of our studies of nearly 40 years—the problem of the cerebral organization of conscious activity of man.

It was the outstanding Russian psychologist, L. S. Vygotski, who showed 40 years ago (116, 117) that complex forms of voluntary organization of conscious actions have a social origin and that it is impossible to understand these forms as an immediate result of biological growth. The formation of voluntary behavior starts in the process of the child's interaction with adults. The adult gives the child a verbal instruction that is accompanied by an immediate practical gesture; the child fulfills this instruction. Thus, at the very beginning, the child's voluntary action is *divided between two persons*, the adult, who starts the action, and the child, who realizes it. Only after the child acquires its own speech does it begin to give verbal instruction to himself, and *the action, which was divided between two persons, becomes an inner organization of the action of the child*. After the child's speech becomes interiorized, the conscious action, mediated by inner speech, becomes a well-developed internal mental act (117, 118–123).

Such revision of our basic concepts of voluntary activity started a long series of researches where the regulative function of speech and its development in the child was studied. These experiments showed the successive stages of the development of the controlling form of speech and its deterioration in abnormal children (122–128). These studies opened new pathways to the analysis of the *brain organization of programmed, conscious activities of man*. The data obtained were published (1–3, 118–125). I shall give only a short summary of the basic data.

Lesions of the prefrontal parts of the human brain do not result in any defects in sensory, motor, or speech functions. Nevertheless that does not mean that the prefrontal parts of the brain do not play an important role in the organization of human behavior. Massive lesions of the frontal lobe result in a marked deterioration of the complex forms of conscious behavior controlled by programs that are organized with the participation of external or internal speech. Higher, goal-linked forms of behavior are easily broken down and replaced by either impulsive actions or imitations of immediately perceived movements (echopraxic reaction), or—as is often observed—by inert repetitions of stereotypes.

These facts are shown in experiments made by K. Pribram and others in the (US) and by Anokhin (126) in the USSR. The same data were obtained in observations of patients with massive lesions of the frontal lobes. These observation showed that in these patients, significant disturbances can be seen even in *simple motor reactions* evoked by verbal instructions; these defects are observed even more in complex *reactions of choice*. Thus, even a simple instruction, "lift your hand," "press my fingers," or more complicated instructions, "when you see a light, you will press the key," do not result in a required movement. The patient who gives one or two adequate motor reactions ceases to do it, repeating echolalically the verbal instruction, which does not result in any movement, or he perseveringly repeats the same movements many times (127). This defect is seen even in a more expressive form in *choice* reactions. If the patient is instructed to lift his right hand after one knock is given and his left hand after two knocks, he either repeats these knocks echopraxically or he starts a stereotype repetition of lifting his right and his left hand independently of the signals (128). Of importance is the fact that a stable motor reaction, which cannot be evoked by preliminary verbal instruction, can be easily obtained in a mechanical way, by a series of subsequent reinforcements (129–131).

A severe deterioration of behavior in patients with massive lesions of the frontal lobes can be observed when the inner meaning of the stimulus comes in conflict with its immediate influence. These data are obtained in experiments when an instruction is given to the patients, "If a weak sound is presented, you will react with a strong movement, and if the signal is strong, your motor reaction has to be smooth"; or "If I show you a fist, you will lift your finger," and if I show you a finger, you will lift your fist." In these cases normal persons (as well as patients with lesions of the posterior parts of the brain) very easily give the appropriate reaction, whereas patients with massive lesions of the frontal lobes repeat the signal, giving an "echopraxic" movement (132–134). As was shown in experiments dealing with the analysis of active search and the attempts to find proper programs needed for solution of the problem given, patients with lesions of the frontal lobes show symptoms of very marked deterioration. Their active searching activity is replaced by impulsive trials or by inert stereotypes (135), and their constructive actions become severely destroyed (136, 137). Similar defects are observed in complex forms of verbally organized intellectual activities, such as in analysis of complex paragraphs (138), in problem-solving behavior, and especially in solving of simple mechanical problems that can serve as a model for every intellectual act (139, 140).

I have given only a short summary of very extensive series of observations made during the last few decades. It shows that *the frontal lobes of the human brain play a very important role in organization and control of complex forms of programmed conscious behavior*.

Neuropsychology of human memory

About 20–30 years ago, there were very few studies on the neurological basis of memory, but during the last two decades—after the classical biochemical works of Hyden and physiological studies on the neuronal level started by the studies of Hubel and Wiesel—the whole situation in this field of science changed fundamentally. Specific neurons were described in the limbic system (hippocampus) and caudate nucleus that did not react to modality-specific influences and that served as comparers of the past and present stimuli and became known as "attention units" (Jasper) or as "memory neurones" (141). A careful functional analysis was made by Soviet psychologists, especially by O. S. Vinogradova (142, 143), who elaborated a theory of the functional architectonics of these units and who made certain significant steps in a designation of the role played by this system in retention and comparison of signals that enter the brain.

Important observations were completed during the last decades in neuropsychological analysis of memory disturbances resulting from lesions of hippocampus, hypothalamus, and mamillary bodies and from the alteration of the circulation of excitation in the "Papez circle"; the outstanding works of Scovill and Milner, Zangwill, Talland, and Warrington and Weiskrantz made important contributions to this field of neuropsychology.

Some problems remain unsolved in these important publications. The contribution to the memory process of different parts of the brain and the different roles played by convexital and mesial parts of the cortex in mnestic processes were un-

known. Whether the pathological loss of memory traits is due to trace decay or to other physiological mechanisms was still uncertain. The kind of memory defects observed in different localization of brain lesions and the levels of the organized traces that suffer in different brain lesions were not clear. Reliable answeres to these questions could be obtained only after a careful psychological analysis of the kind of memory defects observed in local brain lesions, i.e., by careful *psychological qualification* of the memory disturbances observed in these cases.

All these problems were studied in experiments that were reviewed in publications that either appeared during the last few years or are in press (144, 145).

The first goal of neuropsychological studies of memory disturbances in local brain lesions was to show which differences are observed in patients with lesions of convexital parts of the brain cortex and the deep regions of the brain, including structures of the oldest cortical formations. Data obtained by these studies showed some basic differences. Lesions of the posterior parts of the convexital cortex resulted as a rule in clear modality-specific memory disturbances—disturbances of acousticoverbal memory in lesions of the left temporal zones (146, 147) and of opticospatial memory (or quasispatial symbolic memory) in lesions of the parieto-occipital parts of the cortex (1, 3, 148). At the same time, lesions of the deep parts of the brain and of the paleocortical formations resulted in general, modality-unspecific, disturbances of memory. If the lesion is situated in hippocampal regions, these memory defects were not associated with deterioration of consciousness. A different picture was seen in patients when these lesions were massive when the thalamic and hypothalamic region was deranged or when frontal lobes were involved in pathological process. Here severe disorientation in immediate situation and time was observed, and sometimes symptoms of general confusion of consciousness could be seen.

Neuropsychological investigations provided some important data for a better understanding of the physiological mechanisms of *forgetting*, which is observed in local brain lesions. A comparative study of immediate retrieval of traces once established, of their retrieval after pauses of 1–2 min not filled by any additional activities ("empty pauses"), and of their retrieval after pauses filled by some interfering activities (by heterogeneous forms of activities or by similar, homogeneous activities) was made. It showed that the process of remembering of information after "empty pauses" does not show significant defects even in patients with severe deterioration of memory, and that their memory defects are not due to a simple "trace decay." However, every "heterogeneous" or "homogeneous" interference resulted in marked defects of the retrieval of former traces. Thus, patients who easily retained a series of four or five words (or other elements) were unable to retrieve the first group of two or three words that were presented separately after they tried to retain the second group of two or three words. The influence of the "homogeneous interference" acting as a retroactive inhibition worked as a strong blocking agent, and the influence of such an agent on retrieval proved to increase in pathological states of the brain. That showed that the pathological states of the brain result in a pathologically increased inhibition of the retrieval of traces by the interfering influences, and that this pathologically increased interference is a basic mechanism underlying, for most memory disturbances in local brain lesions (144, 145, 149–154).

These data still require control experiments that can show alteration of neurophysiological mechanisms underlying defects of memory in deep lesions of the brain. Such investigations are in progress, and they show significant defects in lowering of the tone of cortical processes and paradoxical changes of relations of brain-stem and cortical components observed in patients with memory disturbances.

Neuropsychological studies conducted during the last years show a basically *different structure* of mnestic defects in patients with different local brain lesions and some important differences in the *level* of these defects. The most important data were obtained in studies with retention of complex verbal material (paragraphs). Patients with lesions of the left temporal lobes could easily retain the general meaning of a whole paragraph, but were unable to retrieve separate words and gave a series of confusions of related word meanings. Patients with lesions of the left parieto-occipital zones and "semantic aphasia" retained the meaning of the whole paragraph as well as of separate words, but were unable to retrieve relational grammatical constructions. Patients with deep lesions of the brain (hypophysis tumors with parasellar growth, hippocampus lesions) retained isolated parts of the paragraph, but very easily lost other parts of the verbal pattern, preserving the whole meaning of the story (145, 149–154). Patients with deep lesions of the middle line of the brain with involvement of the hypothalamus and the frontal lobes gave a very different picture: the process of active remembering became destroyed and selectivity of mental traces was lost, closed logical systems were broken down and replaced by systems open to every influence—the influence of immediate impressions, inert stereotypes, outside associations—and marked disturbances of consciousness and contabulations were observed (145, 149, 150). Very important findings were made in patients with massive deep lesions of the frontal lobes; here every active attempt to retrieve former traces became destroyed, no active mnestic behavior was observed, and pathological stereotypes replaced the goal-lined organized mnestic actions (145, 149).

Neuropsychological studies of memory disturbances associated with local brain lesions opened new pathways to an objective study of the most complex forms of man's active behavior, as well as to an analysis of intimate processes of decoding and retrieval of complicated logicogrammatical structures.

Neuropsychology of the restoration of higher cortical functions

The last chapter of neuropsychology deals not with diagnosis of local brain lesions, but with a scientific approach to the restoration of higher cortical functions (speech, reading, writing, etc.) destroyed after focal lesions of the brain. For a long time it was thought that no real restoration of higher cortical functions after local brain lesions could be seen. If a mental "function" is associated with a circumscribed group of neurons, their destruction leads to inevitable loss of function that cannot be restored. The revision of our basic concepts of higher cortical functions and the idea that they really are complex and flexible functional systems, changed this hypothesis fundamentally.

If these functional systems are the result of a flexible constellation of different cortical zones, it can be hypothesized

that the disorganization of the functional system resulting from a focal lesion can be compensated by a *reorganization of these functional systems* and by inclusion of new preserved links in the deranged system. That was the basic assumption started with in studies started after World War II and continued for many years (see 1–3, 61–63, 155–165).

Every local lesion of the brain has a double result: some functions, immediately associated with the damaged foci, are broken down; others are temporarily blocked because of the process of "diaschisis" or a temporary inhibition due to a disturbance of the process of synaptic conduction or a "functional asynapsia" (166). That is why every restoration of higher cortical functions disturbed after focal brain lesions can be done by two different methods. Functions that were only temporarily blocked can be restored in their previous form by means of certain pharmacological treatment that can restore the synaptic conduction; the experience obtained during World War II (166, 167) and observations on children with cerebral palsy (168) showed that anticholinesterase factors (such as prostigmin, nevalin, etc.) can be used with success to eliminate the over-production of cholinesterase and to relieve the synaptic block resulting in motor or sensory defects. Sometimes pure psychological means, such as the inclusion of the temporarily blocked function in a preserved form of complex activity, can result in a "deblocking" of the temporarily inhibited function; (169–172).

A different method is needed to restore the whole functional systems deranged by destruction of some zones of the cortex. In these patients, an elaborate program of *rehabilitative training* is needed, and only a carefully *planned reorganization of functional systems* that include new, preserved links can provide a restoration of the disturbed function. Such a system of programmed rehabilitation of functions was elaborated in neuropsychological studies in the USSR and was described in a series of publications (158–160, 164, 175, 176).

These principles of the reorganization of functional systems deranged after local injury gave a scientific basis for the restoration of movements (173, 174), speech, writing, and reading (61, 158–164), computation (79), constructive activity (137, 165), problem-solving behavior, and intellectual actions (138–140, 158, 163). The process of scientifically based restoration of these activities requires a careful psychological qualification of the defect, finding proper ways for adequate reorganization of the functional system, and planning a step-by-step organized sequence of orthopsychological methods. They start with an application of a series of external aids and gradually come to an interiorization of the process to be recovered. The psychological theory that can serve as a basis of such rehabilitation of damaged functional system was carefully elaborated in Soviet psychology (177–179).

Neuropsychology is now one of the most important fields of behavioral sciences. Its progress is of great importance for the further development of the scientific approach to basic problems of the analysis of human behavior.

86. Gey Walter, W. (1966) "The role of the frontal lobes in the regulation of activity," in *Frontal Lobes and the Regulation of Psychological Processes*, eds. Luria, A. R. & Homskaya, E. D. (Moscow University Press), pp. 156–175 (Russian).
87. Livanov, M. N., Gavrilova, N. A. & Aslanov, A. S. (1964) "Intercorrelation between different cortical regions of the human brain during mental activity," *Neuropsychologia* **2**, 281–289.
88. Livanov, M. N. (1972) *Spatial Organization of the Processes in the Brain* ("Nauka" Publ. House, Moscow), (Russian).
89. Luria, A. R. & Homskaya eds. (1972) *Frontal Lobes and the Regulation of Psychological Processes* (Moscow University Press).
90. Pribram, K. H. & Luria, A. R. eds. (1973) *Behavioral Physiology of the Frontal Lobes* (Academic Press, New York).
91. Homskaya, E. D. (1972) *Brain and Activation* (Moscow University Press) (Russian).
92. Luria, A. R. & Homskaya, E. D. (1970) "Frontal lobes and the regulation of arousal processes," in *Attention*, ed. Mostofski, D. (Appleton–Century–Crofts, New York).
93. Sokolov, E. N. (1963) *Perception and Conditional Reflex* (Macmillan, New York).
94. Sokolov, E. N. (1967) *The Mechanisms of Memory* (Moscow University Press) (Russian).
95. Sokolov, E. N. (1958) "Orienting reflex, its structure and mechanisms," in *Orienting Reflex and Orienting-Exploratory Activity* (Academy Pedagog. Sciences Press, Moscow), pp. 111–123 (Russian).
96. Sokolov, E. N. ed. (1959) *Orienting Reflex and Problems of Higher Nervous Activity* (Academy Pedagog. Sciences Press, Moscow) (Russian).
97. Sokolov, E. N. ed. (1964) *Orienting Reflex and Problems of Perception in Normal and Pathological Conditions* ("Prosveschenie" Publishers) (Russian).
98. Sokolov, E. N. & Vinogradova, O. S. eds (1970) *Neuronal Mechanisms of the Orienting Reflex* (Moscow University Press) (Russian).
99. Vinogradova, O. S. (1959) "The role of the orienting reflex in the formation of conditioned reflexes," in *Orienting Reflex and Problems of Higher Nervous Activity*, ed. Sokolov, E. N. (Moscow University Press), pp. 86–160 (Russian).
100. Baranovskaya, O. P. & Homskaya, E. D. (1966) "Changes of the frequency spectrum of the EEG associated with indifferent and significant stimuli in normal subjects and in patients and lesions of the frontal lobes," in *Frontal Lobes and the Regulation of the Psychological Processes*, eds. Luria, A. R. & Homskaya, E. D. (Moscow University Press), pp. 254–276 (Russian).
101. Baranovskaya, O. P. (1968) *The Influence of Voluntary Attention in the Frequencies of the EEG (Alpha Waves) in Normal Subjects and in Patients with Lesions of the Frontal Lobes*, Candid. Dissert. Moscow University.
102. Genkin, A. A. (1962) "On the asymmetry of the ascending and descending phases of the EEG-waves of the posterior parts of the cortex in normal subjects," *Proc. (Doklady) Acad. Pedagog. Sci.* **N4**, 99–102 (Russian).
103. Genkin, A. A. (1963) "On the asymmetry of the phases of the EEG associated with active thought," *Proc. (Doklady) Acad. Sci. USSR* **149**, 1460–1463 (Russian).
104. Artemieva, E. Yu. (1965) *Periodic Oscilations of the Asymmetry of the EEG-Waves As an Indicator of the State of Activity*, Candid. Dissert. Moscow University (Russian).
105. Artemieva, E. Yu. & Homskaya, E. D. (1966) "The measurement of the asymmetry of the EEG-waves in different functional states in normal subjects and in patients with lesions of the frontal lobes," in *Frontal Lobes and the Regulation of Psychological Processes*, eds. Luria, A. R. & Homskaya E. D. (Moscow University Press), pp. 294–313 (Russian). [English text (1972) in *Behavioral Physiology of the Frontal Lobes*, eds. Pribram, K. H. & Luria, A. R. (Academic Press, New York).]
106. Peymer, J. A. (1958) "On the local bioelectrical responses of the human cortex and their relations to the generalized reaction in the formation of the conditioned reflex," *Physiol. J. USSR* **44**, 829 (Russian).
107. Farber, D. A. (1969) *Functional Growth of the Cerebrum in Early Ontogenesis* ("Prosveschenie" Publishers. Moscow) (Russian).
108. Farber, D. A. & Alferova, V. V. (1972) *Electroencephalograms of Children and Juveniles* ("Pedagogica" Publishers. Moscow) (Russian).

109. Farber, D. A. & Fried, G. M. (1971) "Linked attention and evoked potentials in school children," *J. Higher Nervous Act.* **21,** 1056–1062 (Russian).
110. Fried, G. M. (1972) *EEG-Analysis of the Perception of Visual Signals Associated with the Orienting Reaction and Linked Attention in School Children,* Candid. Dissert (Academy Pedagog. Sciences Press, Moscow) (Russian).
111. Simernitskaya, E. G. (1970) *Studies in Regulation of Activity by the Method of Evoked Potentials* (Moscow University Press) (Russian).
112. Simernitskaya, E. G. & Homskaya, E. D. (1966) "Changes of the parametra of the evoked potentials associated with changes of the significance of the stimuli in normal subjects and in patients with lesions of the frontal lobes," in *Frontal Lobes and the Regulation of Psychological Process,* eds. Luria A. R. & Homskaya E. D. (Moscow University Press), pp. 277–293 (Russian). [English text (1972) in *Behavioral Physiology of the Frontal Lobes,* Pribram, K. H. & Luria, A. R. (Academic Press).
113. Filippycheva, N. A. & Faller, T. O. (1970) "On the functional states of human brain in gliomas of the mesial parts of hemispheres," *Korsakow's J. Neuropath. Psychiat.* **70,** 646–654 (Russian).
114. Kamenov, D. A. & Filippycheva, N. A. (1972) "The dynamics of blood flow associated with orienting reflexes in man," *J. Higher Nervous Act.* **22,** 385–393 (Russian).
115. Vygotski, L. S. (1956) *Selected Psychological Studies* (Academy Pedagog. Sciences Press, Moscow) (Russian).
116. Vygotski, L. S. (1960) *Development of the Higher Psychological Functions* (Academy Pedagog. Sciences Press, Moscow) (Russian).
117. Vygotski, L. S. (1966) "Development of the higher mental function," in *Psychological Research in the USSR* (Progress Publishers, Moscow), pp. 11–45.
118. Luria, A. R. (1969) *The Origin and the Brain Organization of Man's Conscious Activity,* Evening lecture to the XIX Int. Congr. Psychology, Proceedings of the Congress (Brit. Psychol. Society, London), pp. 37–54.
119. Luria, A. R. (1960) "Verbal regulation of behavior," in *The Central Nervous System and Behavior,* ed. Brazier M., J. Macy Jr. Foundation Symposium, New York, pp. 359–420.
120. Luria, A. R. (1961) *The Role of Speech in the Regulation of Normal and Abnormal Behavior* (Pergamon Press, Oxford).
121. Luria, A. R. ed. (1956, 1958) *Problems of the Higher Nervous Activity in the Normal and Abnormal Child* (Academy Pedagog. Sciences Press, Moscow), Vol. I–II. (Russian).
122. Luria, A. R. (1957–1959) "On the formation of the voluntary movements in children," *Proc. (Doklady) Acad. Pedagog Sci.,* **1957 N1,** 79–84; "Observations on the development of the vountary action in early childhood," *Proc. (Doklady) Acad. Pedagog. Sci.,* **1959 N3,** 75–80, **N4,** 57–62, **N6,** 59–62 (Russian).
123. Luria, A. R. (1959) "The directive function of speech in development and dissolution," *Word* **15,** 341–352 and 453–464, and (1967) in *Research in Verbal Behavior and Some Neurophysiological Implications,* eds. Salzinger K. & Salzinger S. (Academic Press, New York), pp. 405–422.
124. Luria, A. R. ed. (1963) *The Mentally Retarded Child* (Pergamon Press, Oxford).
125. Luria, A. R. & Homskaya, E. D. (1964) "Disturbances in the regulative role of speech with frontal lobe lesions," in *The Frontal Granular Cortex and Behavior,* eds. Warren J. M. & Akert K. (McGraw Hill, New York), pp. 353–371.
126. Anokhin, P. K. (1949) *Problems of Higher Nervous Activity* (Academy Med. Sci. Press, Moscow).
127. Mescheriakov, A. J. (1966) "Disturbances of simple motor reactions in massive lesions of the frontal lobes," in *Frontal lobes and Regulation of Psychological Processes,* eds. Luria, A. R. & Homskaya, E. D. (Academy Pedagog. Sciences Press, Moscow), pp. 431–445 (Russian).
128. Ivanova, M. P. (1966) "Disturbances of reaction of choice in massive lesions of the frontal lobes," in *Frontal Lobes and Regulation of Psychological Processes,* eds. Luria, A. R. & Homskaya, E. D. (Academy Pedagog. Sciences Press, Moscow), pp. 445–462 (Russian).
129. Homskaya, E. D. (1966) "Regulation of intensity of voluntary motor reactions in lesions of the frontal lobes," in *Frontal Lobes and Regulation of Psychological Processes,* eds. Luria, A. R. & Homskaya, E. D. (Academy Pedagog. Sciences Press, Moscow), pp. 463–499 (Russian).
130. Maruszewski, M. (1966) "Disturbances of the simple forms of voluntary movements in focal lesions of the frontal lobes," in *Frontal Lobes and Regulation of Psychological Processes,* eds. Luria, A. R. & Homskaya, E. D. (Academy Pedagog. Sciences Press, Moscow), pp. 500–522 (Russian).
131. Ioshpa, A. Ya. & Homskaya, E. D. (1966) "Regulation of the temporal parametra of voluntary motor reactions in lesions of the frontal lobes," in *Frontal Lobes and Regulation of Psychological Processes,* eds. Luria, A. R. & Homskaya, E. D. (Academy Pedagog. Sciences Press, Moscow), pp. 523–553 (Russian).
132. Luria, A. R. (1968) "Two types of motor perseveration in massive lesions of the frontal lobes," *Brain* **88,** 1–10.
133. Luria, A. R., Pribram, K. H. & Homskaya, E. D. (1964) "An experimental analysis of the behavior of disturbances produced by a left frontal arachnoidal endothelioma (meningeoma)," *Neuropsychologia* **2,** 257–280.
134. Lebedinsky, V. V. (1966) Performance of symmetrical and asymmetrical programs in patients with lesions of the frontal lobes," in *Frontal Lobes and the Regulation of Psychological Processes,* eds. Luria, A. R. & Homskaya, E. D. (Moscow University Press), pp. 576–603 (Russian).
135. Tikhomirov, O. K. (1966) "Disturbances in programs of active search behavior in patients with lesions of the frontal lobes," in *Frontal Lobes and the Regulation of Psychological Processes,* eds. Luria A. R. & Homskaya E. D. (Moscow University Press), pp. 604–617 (Russian).
136. Gadjiev, S. G. (1966) "Disturbances in constructive intellectual activity in lesions of the frontal lobes," in *Frontal Lobes and the Regulation of Psychological Processes,* eds. Luria A. R. & Homskaya E. D. (Moscow University Press), pp. 618–640 (Russian).
137. Tsvetkova, L. S. (1966) "Disturbances in constructive intellectual activity in lesions of the occipitoparietal and of frontal lesions of the brain," in *Frontal Lobes and the Regulation of Psychological Processes,* eds. Luria A. R. & Homskaya E. D. (Moscow University Press), pp. 641–663 (Russian).
138. Tsvetkova, L. S. (1966) "Disturbances in paragraph analysis in patients with lesions of the frontal lobes," in *Frontal Lobes and the Regulation of Psychological Processes,* eds. Luria A. R. & Homskaya E. D. (Moscow University Press), pp. 664–676 (Russian).
139. Tsvetkova, L. S. (1966) "Disturbances in arithmetical problem solving in patients with lesions of the frontal lobes," in *Frontal Lobes and the Regulation of Psychological Processes,* eds. Luria A. R. & Homskaya E. D. (Moscow University Press), pp. 677–705 (Russian).
140. Luria, A. R. & Tsvetkova, L. S. (1967) *Les Troubles de Résolution de Problemmes* (*Analyse Neuropsychologique*) (Gautier–Villars, Paris).
141. Sokolov, E. N. (1969) *Mechanisms of Memory* (Moscow University Press) (Russian).
142. Vinogradova, O. S. (1965) "Dynamic classification of neurones of the hippocampus and sensory stimuls," *J. Higher Nervous Act.* **15,** 500–512 (Russian).
143. Vinogradova, O. S. (1970) "Hippocampus and orienting reflex, in *Neuronal Mechanisms of the Orienting Reflex,* eds. Sokolov E. N. & Vinogradova O. S. (Moscow University Press), pp. 183–215.
144. Luria, A. R. (1971) "Memory disturbances in local brain lesions," *Neuropsychologia* **9,** 369–375.
145. Luria, A. R. (1973) *Neuropsychology of Memory* ("Pedagogica" Publishers, Moscow), Vol. I; Vol. II, in press (Russian).
146. Luria, A. R., Sokolov, E. N. & Klimkovski, M. (1967) "Towards a neurodynamic analysis of memory disturbances

in lesions of the left temporal lobes," *Neuropsychologia* **5,** 1–11.

147. Klimkovski, M. (1965) *Disturbances of Acousticoverbal memory in Local Brain Lesions,* Candid. Dissert. Moscow University (Russian).
148. Pham Ming Hac (1971) *Types of Memory Disturbances in Lesions of the Convexital Parts of the Left Hemisphere,* Candid. Dissert. Moscow University (Russian).
149. Luria, A. R., Konovalov, A. N. & Podgornaya, A. Y. (1970) *Memory Disturbances Associated with Aneurisms of the Anterior Cerebral Artery* (Moscow University Press) (Russian).
150. Popova, L. T. (1972) *Memory Disturbance in Focal Brain Lesions.* Meditsina Publishers, Moscow (Russian).
151. Kiyaschenko, N. R. (1969) *Structure of Memory Disturbances in Local Brain Lesions,* Candid. Dissert. Moscow University (Russian).
152. Kiyaschenko, N. R. (1973) *Memory Disturbances in Local Brain Lesions* (Moscow University Press) (Russian).
153. Akbarova, N. A. (1971) *Neuropsychological Analysis of Amnestic Syndromes in Cerebral Trauma,* Candid. Dissert. Academy of Medical Sciences of the USSR (Russian).
154. Marzaganova, M. A. (1971) *Memory Disturbances in Vascular Disorders in Later Maturity,* Candid. Dissert. Institute of Psychiatry Moscow (Russian).
155. Rubinstein, S. L. ed. (1947) "Problems of the restoration of psychophysiological functions," *Proc. Moscow Univ.* **111.**
156. Luria, A. R. & Leontiev, B. N. (1947) "Psychophysiological ways of the restoration of functions after war trauma," *Proc. Moscow Univ.* **111,** 17–31 (Russian).
157. Luria, A. R. (1950) "Psychology and the reorganization of brain functions," *Proc. Bielorussian Acad Sci.* **N2,** 45–57 (Russian).
158. Luria, A. R. (1948) *Restoration of Functions After Brain Injury* (Pergamon Press, Oxford).
159. Luria, A. R. (1960) "Researches in brain injuries and restoration of functions," in *Psychological Science in the USSR* (Academy of Pedagog. Sciences Press, Moscow), pp. 428–548 (Russian). [English text (1969) in *A Handbook of Contemporary Soviet Psychology,* eds. Cole, M. & Maltzman, I. (Basic Books), pp. 277–301.
160. Luria, A. R., Naydin, V. L., Tsvetkova, L. S. & Vinarskaya, E. N. (1969) "Restoration of higher cortical functions following local brain damage," in *Handbook of Clinical Neurology,* eds. Vinken, P. I. & Bruyn, G. W. (North–Holland Publish. Cic., Amsterdam), Vol. 3, pp. 368–433.
161. Luria, A. R. & Tsvetkova, L. S. (1968) "The reeducation of brain-damages of patients and its psychopedagogical application," in *Learning Disorders* (Special Child Publication, Seattle), Vol. 3, pp. 139–154.
162. Tsvetkova, L. S. (1971) "Goals of the rehabilitative education," *Korsakow's J. Neuropath. Psychiat.* **71,** 816–821 (Russian).
163. Tsvetkova, L. S. (1970) "Scientific bases of the rehabilitative education," *Soviet Pedagogics* **N6,** 64–79.
164. Tsvetkova, L. S. (1972) *Rehabilitative Education in Local Brains Lesions* ("Pedagogica" Publishers, Moscow) (Russian).
165. Luria, A. R. & Tsvetkova, L. S. (1964) "The programming of constructive activity in local brain injuries," *Neuropsychologiy* **2,** 95–108.
166. Graschenkov, N. I. (1948) *Inter-neuron Apparatuses of Connections (Synapses) and Their Role in Physiology and Psychology* (Minsk, Bielorussian Acad. Press) (Russian).
167. Perelman, L. B. (1947) "Physiological ways of restitution in Trauma," *Proc. Moscow Univ.* **111,** 58–62 (Russian).
168. Eidinova, M. B. & Pravdina–Vinarskaya, Ye. N. (1963) *Cerebral Palsy in Children and Its Treatment* (Pergamon Press, Oxford).
169. Weigl, E. (1961) "The phenomenon of temporal deblocking-in aphasia," *Z. Phonet. Sprachwiss. Kommunikationsforsch.* **14,** 337–364.
170. Weigl, E. (1963) "Die Deblockierung Bildagnostischen Störungen bei einem Aphatischen," *Neuropsychology I,* 91–107.
171. Weigl, E. (1964) "Die Bedeutung der verbo-kinethischen Erregungen des Sprachapparates bei Normalen und Sprachgestörten," *Cortex I,* 77–90.
172. Weigl, E. (1964) "Experimental de-blocking of the verbal defects as a method of studies of cerebral dynamics," *Questions of Psychology* **N4,** 149–159 (Russian).
173. Leontiev, A. N. & Zaporozhets, A. V. (1960) *Rehabilitation of Hand Functions* (Pergamon Press, Oxford).
174. Naydin, V. L. (1972) *Rehabilitation of Neurosurgical Patients with Disorders of Movements* ("Meditsina" Publishers, Moscow) (Russian).
175. Kogan, V. M. (1947) "Restoration of the word meaning in aphasia," *Proc. Moscow Univ.* **111,** 151–153 (Russian).
176. Kogan, V. M. (1962) *Restoration of Speech in Aphasia* (Central Institute of Invalide Expertise Press, Moscow) (Russian).
177. Galperin, P. Ya. (1965) *Basic Results of the Investigations of the Formation of Mental Actions and Concepts,* Doctoral Dissert. Moscow University (Russian).
178. Galperin, P. Ya. (1966) "Psychology of thinking and the theory of step-by-step formation of mental acts," in *Researches in Thinking in Soviet Psychology,* ed. Shorokhova, E. V. ("Nauka," Publishing House, Moscow), pp. 236–277.
179. Galperin, P. Ya. (169) "Stages in the development of mental acts," in *A Handbook of Contemporary Soviet Psychology,* eds. Cole, M. & Maltzman, I. (Basic Books, New York), pp. 249–278.