

# A HISTORY OF PSYCHOLOGY IN AUTOBIOGRAPHY

## Volume VI

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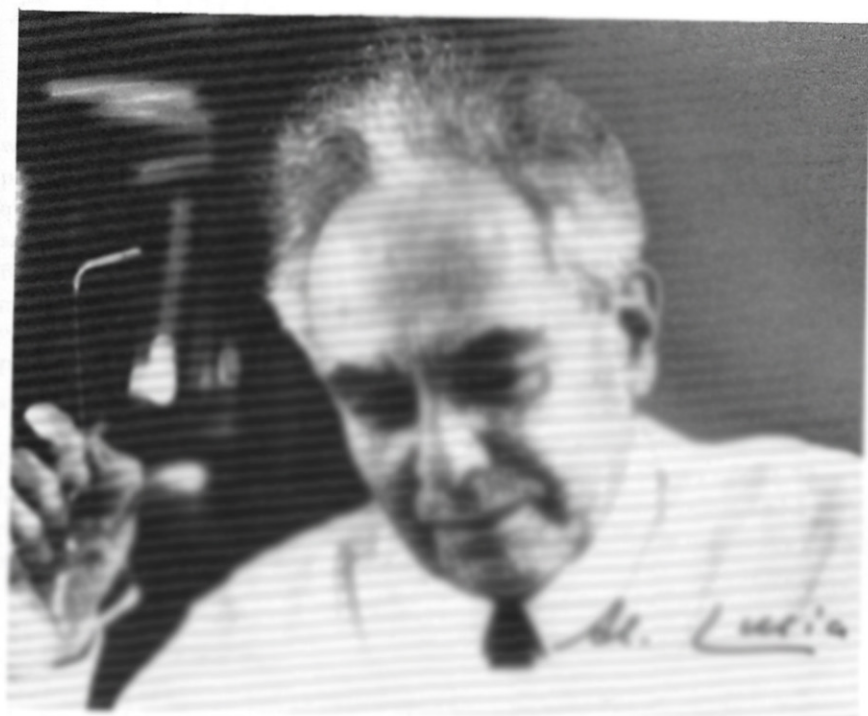
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# A. R. Luria

The work presented here was preceded by an interesting correspondence which explains its appearance. In 1963 Professor E. Boring proposed that I participate in the preparation of *A History of Psychology in Autobiography*. I questioned the appropriateness of only one Russian autobiography when Soviet science should be represented by, at least, a few investigators and Professor Boring proposed that I and colleagues whom I named submit our written material to be held until 1970. "If you live to 1970," wrote Professor Boring, "the material you have written will go in the next volume of *A History of Psychology in Autobiography*. If you die before then, it will be published as an autonecrology."

Professor Boring's invitation seemed more than a superfluous diversion. In fact, retrospective analysis of the road one has traveled is always useful. Therefore, I have responded to the proposition with complete seriousness and I have prepared the present material in order that it might be useful in one or the other of the forms proposed by Professor Boring.

## INTRODUCTION

It certainly does not seem essential that a participant in the volume *A History of Psychology in Autobiography* write autobiographical notes on the assumption that he must recount all the events of his life. This would be not only insufficiently modest but also beside the point. A series of such autobiographical sketches would not be likely to result in a true picture of the history of science.

Individual people come and go, contributing some, to them insufficiently distinctive, bits of knowledge to the general enterprise. The real interest lies in the conditions in which they lived, the ideas which made up the scientific atmosphere of their time, and the influence of those important people whose experience they incorporated into themselves.

Translated by Michael Cole, The Rockefeller University.

That is why these pages will be least of all an attempt at an autobiography; rather, they will be much more occupied with a description of the period in which the author lived and a biography of the people who were decisive influences in the development of the psychological science of which he was a part.

The following *vita* should be sufficient for the purpose of summarizing biographical data. I was born in 1902, in Kazan, one of the oldest cultural centers of the Eastern part of European Russia, into a doctor's family. My father was a well-known and talented therapist who, after the Revolution, became one of the leading figures in Soviet medicine and who headed the Department of Therapy first in Kazan and then in Moscow. I graduated from Kazan University in 1921 with a degree in the humanities and immediately began to work in psychology. Recognizing the significance which natural science preparation has for the study of psychology, I entered the medical faculty of Kazan University. However, I did not complete my medical education until 1936, at the First Medical Institute in Moscow.

In 1923 I moved to Moscow and began to work in the Institute of Psychology of Moscow University, which was then directed by Professor K. N. Kornilov. It was here that I met L. S. Vygotsky, who was to become a decisive influence in all of my later life.

In the first years I devoted my work to the objective investigation of emotional processes with the aid of the combined motor method which I invented for this purpose. At the same time I taught and did research in the Department of Psychology of the N. K. Krupskaya Academy of Communist Education.

In 1931, I, along with L. S. Vygotsky and A. N. Leont'ev, founded the Center of Psychology of the Ukrainian Psychoneurological Academy, where I worked for three years in addition to carrying on my work in Moscow.

In the period 1934 to 1936 I began to work on developmental psychology at the Moscow Medical Institute of Genetics, where I headed the section on psychology and carried out a series of experiments on the analysis of psychological processes in identical twins with the purpose of clarifying how the relation between genetic and environmental factors changes during the course of the child's development.

In 1936 I switched into the area of neuropsychology. I created the Laboratory of Neuropsychology in the Institute of Neurosurgery (later the N. N. Burdenko Institute of Neurosurgery) and began to develop neuropsychological methods for the investigation of localized brain damage.

At the time of World War II I continued this work, heading the Neurosurgical Restoration Hospital in the Urals and then, returning to Moscow, I continued to carry on this work in the Institute of Neurosurgery. The only departure from this course was in the period 1953-1959, when I carried out psychophysiological investigations of anoma-

lous children in the Institute of Defectology of the Academy of Pedagogical Sciences.

Throughout all this time I combined research and teaching as Professor of the Department of Psychology of Moscow University, where for many years I taught the basic course on psychology and directed a large number of students and graduate students. At the present time I head the Department of Neuropsychology in the Faculty of Psychology at Moscow University.

In 1936 I defended my dissertation for the degree of Doctor of Pedagogical Sciences (in Psychology) and in 1943 a dissertation for the degree of Doctor of Medical Sciences. In 1967 I received the Honorary Degree of Doctor of Science at Leicester University (England) and at Nijmegen University (The Netherlands). I was chosen in 1945 as a corresponding member and in 1947 a full Member of the Academy of Pedagogical Sciences of the RSFSR (then of the USSR). I became a foreign member of the American Academy of Arts and Sciences in 1966, of the American Pedagogical Academy in 1967, and of the National Academy of Sciences of the United States in 1968.

As one of the organizers of the Soviet Society of Psychologists I headed for many years its section on psychophysiology and medical psychology. In 1960 I was made an honorary member of the British Psychological Association and later an honorary member of the Switzerland Psychological Society, Columbian Psychological Society, and the French Neurological Society. I have for many years been a member of the editorial board of *Problems in Psychology* and in recent years have been coeditor of the journals *Neuropsychology*, *Cortex*, *Cognition*, et al. In 1966 I served as a Chairman of the Program Committee of the XVIII International Psychological Congress in Moscow, and 1969-1972 as Vice-President of the International Union of Psychological Sciences.

## ATMOSPHERE

The scientific atmosphere of Soviet Russia in the twentieth century, as many authors have noted, was very unusual, not to say unique. The greatest social revolution ever to take place had just occurred. It had occurred in an economically backward country but one which possessed strong intellectual traditions.

Certain of these traditions, having their roots in Czarist Russia, represented a barrier to the development of scientific thought. One such was the tradition of idealistic philosophy, which isolated the discipline of psychology from other scientific disciplines by maintaining the position that it should not be a subject of natural science, of cause-effect analysis.

The introduction of the techniques of exact psychological experimentation (laboratories of experimental psychology were opened in some Russian universi-

ties in the last decade of the nineteenth century, and the Institute of Psychology was founded in Moscow in 1911) did not defeat these agnostic positions of official philosophy but rather served to strengthen them. The blind alley into which this approach would have led psychology is obvious.

However, in prerevolutionary Russia there existed another, revolutionary tradition, that of the Russian revolutionary democrats of the middle of the nineteenth century, the humanistic tradition of Herzen, Chernishevskii, Dobrolyubov, and Pissarev. Theirs was the tradition of the natural science approach to the mental life of man. It attempted to understand man, his social existence, and his inner world by using those objective methods which had been applied in other sciences.

In the second half of the nineteenth century the latter tradition influenced the formation of I. M. Sechenov's approaches. Sechenov can be considered in equal measure the father of Russian physiology and of scientific psychology. He began with the publication in 1861 of *Reflexes of the Brain*, in which he defended the idea that reflex structures underlie all psychological processes and that it was possible to study them using objective methods. His later works defined psychology as "the science of the formation of mental activities," and in one of his last works, *Physiology of Nerve Centers*, published in the last decade of the nineteenth century, he proposed that science should study complex processes in the development of mental activity, in the course of which "sensations become motives and purposes and movements become actions." Sechenov's appeal to study mental processes objectively and to view them as the product of development became a strong tradition of Soviet psychology.

The studies of I. P. Pavlov and his school, and to some extent the works of V. M. Bekhterev, developed objective methods for the study of the behavior of the whole organism. They marked the beginning of that physiological analysis of the mechanisms of complex mental activity which in many respects defined the general line of development of Soviet psychology in the first half of this century.

However, the work of Pavlov and Bekhterev, which made the physiological analysis of mental phenomena the subject of objective scientific investigation, contained certain limitations. It had not provided an adequate method for the analysis of more complex forms of man's conscious activity—his active behavior, voluntary attention, deliberate remembering, and abstract thinking. Young psychologists of that time were not attracted by the simplified attempts to interpret mechanistically the more complex phenomena of mental life as systems of food or sex reflexes, although this approach received wide attention and popularity in the literature of the 1920s. They doubted the perspectives of a scientific approach which dealt only with elementary psychophysiological processes and left the higher forms of man's conscious activity to the subjective analysis of philosophical idealists or to phenomenological description. Psychology became divided into "explanatory" (the application of scientific criteria to the analysis of elementary forms of mental activity with a consequent neglect of its higher forms) and "descriptive" (the description of higher forms of consciousness,

which, however, rejected approaching them from a natural-scientific, causal point of view). This division, current at the beginning of the twentieth century, did not appeal at all to the young Soviet psychologists in the first decade after the Revolution.

It was necessary to overcome "the crisis in psychology," to try to establish the most complex forms of conscious activity of man as the subject matter of psychology while preserving the objective scientific approach to its analysis and producing a scientific explanation of the appearance and course of the higher forms of mental activity.

The solution of this "crisis" was found in an historical approach to the higher mental functions of man which would attempt to show that the processes of conscious life, interpreted by the idealistic philosophers as a special "world of the mind," were in fact the product of a long social-historical development of the social life of man. It was also held that a scientific approach to understanding the origin and history of higher mental functions could be carried out only by going beyond the limits of a naturalistic analysis of mental phenomena and interpreting them as forms of activity evoked by the social experience of people, their interactions with each other, and their mastery of objectively laid down forms of social life.

The development of new paths in scientific psychology emphasizing the social-historical nature of mental functions, which while reflex in structure were consciously and voluntarily directed in their functional aspects and of social-historical origin, became the undertaking of a group of young investigators led by the great Soviet psychologist L. S. Vygotsky. Without for a minute abandoning the position of an objective approach to mental phenomena, Vygotsky initiated the study of the higher mental functioning of man, and through his students and friends (A. N. Leont'ev, D. B. Elkonin, A. V. Zaporozhets, and others) defined the path of development of Soviet psychology.

## THE 1920s AND EXPERIMENTAL PSYCHOPATHOLOGY

Out of the problems described above was created the scientific atmosphere of the 1920s—the period when the world view of the first generation of Soviet psychologists was established. All these psychologists had experienced dissatisfaction with the academic psychology created prior to the Revolution: its detailed study of separate elementary psychological processes and completely useless approach to any scientific study of the most complex phenomena of mental life. They were all prepared to apply objective methods to the investigation of complex mental activity and implicitly accepted the idea of the reflex nature of mental processes; and they all attempted to find new ways to produce effective analyses of the complex forms of mental life. Certain of them (including myself) who had not come under the influence of any of the existing psychological schools, at one time believed that a scientific approach to the

wholeness of personality was best represented by the new field of psychoanalysis. It was believed that the psychoanalytic approach to the concrete mental life of the individual had found the true path between the extremes of the nomothetic sciences (which interpret general laws but lose their individual features) and the idiographic sciences (which describe the individual features but cannot combine them into general laws). Many thought that the concept of individual lawfulness, the "concrete psychology" studied by Freud and Adler, created the pathway for the scientific approach. This was the subject of a youthful study by the author, "The Foundations of Realistic Psychology" (1922), which remains unpublished and is only of historical interest. However, these young psychologists repudiated the kind of arbitrary interpretation which was already characteristic of psychoanalysis. They did accept the necessity of using objective methods for the analysis of affective states, actual and repressed affective complexes, and for approaching the concrete dynamics of mental life from an objective, physiological position. Thus began the first serious experiments by the author, which were to continue for almost ten years and which culminated in the publication of a series of investigations on the "combined motor method" in *The Nature of Human Conflicts* (1932).

It is well known that the associative processes sometimes occur correctly and quietly, but at other times are accompanied by stress phenomena which disrupt their quiet course. In the inner life of man there can occur affective disturbances leading to the disorganization of human behavior and to neurosis. How can one objectively study these phenomena? How can one establish their symptomology, discover the mechanisms which produce them, and study the means to overcome them?

The attempts of psychoanalysis were fantastic and led it beyond the borders of an exact science. Psychoanalysis did not afford an opportunity to discover a means of determining the "objective symptomology" of the emotional conditions—breathing, pulse rate, and electrophysiological changes—which were only then being discovered. The findings of psychoanalysis were insufficiently reliable, resting on nonessential and unstable indicators of deep processes occurring below consciousness. The development of Soviet objective psychology benefited from the idea of uniting inner (verbal-associative) processes, which can be used to merge affective states into a single functional system, with their outer, motor manifestations, to create a *single dynamic contour* in which the inner changes are necessarily reflected in the outwardly observable motor processes. This is how the "combined motor method" came to be invented. This method, described in a series of reports (Luria, 1928, 1932, etc.), served as the beginning of a widely used approach for the objective study of affective processes. The collection of a large amount of comparative material concerning natural emotional processes, the investigation of criminals (later, in a simplified form modified from the initial method, this work was applied to the construction of "lie detectors"), and studies of neurotics permitted a wide application of objective methods to study affective processes. The application of the tech-

nology to artificially evoked conflicts, including even those in hypnotic states, proved useful for the analysis of certain mechanisms underlying the origin of affective states (Luria, 1932).

Investigations carried out at that time permitted us to replicate with human beings the experiments in which Pavlov had observed "conflicts" and "breaks" in animals. This analysis of experimentally evoked conflicts as a source of intense affective states can be viewed as a contribution to the objective study of the mechanisms of the disorganization of human behavior, even though it was carried out by a group of young psychologists who were just beginning their research careers.

An important fact concerning this work is that the research did not long dwell on the study of the objective symptoms of affective complexes and the physiological conditions which evoke a disorganization of behavior. These investigations very soon began (partly as a result of Vygotsky's influence) to reflect new motifs which were not to be fully developed in Soviet psychology until much later and which became the center of investigation only in the 1950s.

These early researchers came more and more to interest themselves in ways of overcoming affective states, in discovering the means that could be used to gain control of disorganized behavior, to control the affective flareups and reduce conflict.

Now, looking back on these investigations of 40-50 years ago, it is clear that these young scientists took the right path when they decided to study the role played by verbal generalizations in the control of affect. They conducted an extensive series of experiments which represented an approach to the objective mechanisms for the willful control of disorganized behavior. Thus *The Nature of Human Conflicts* was subtitled "Emotion, Conflict and Will," and was devoted to an attempt to demonstrate the role that compensatory mechanisms can play in the organization of human behavior, and the significance of meaningful restructuring of the situation (today we would say re-coding) with the aid of verbal generalizations for the control of conflict and the affective states which conflict evokes. A whole series of studies showed how verbal reorganization of mental processes may lead to the liquidation of "conflicts of inadequacy" or "conflicts of contradiction"; how verbal reorganization of psychological processes leads to the liquidation of stress; and how in the process of the child's development the increasingly complex influence of verbal reorganization of psychological activity leads to the formation of complex, organized forms of "voluntary activity" which takes the place of primitive affects.

It is possible that certain of these studies, although straightforward and not devoid of naivete, retain their significance to the present time. They certainly represent some of the first attempts to study experimentally the role of speech in the organization of behavior. They were early searches for the physiological basis of psychotherapy and the physiological mechanisms of voluntary activity. And even now, nearly fifty years after the beginning of these experiments, I remember with a feeling of gratitude the attention my friend and teacher, L. S.

Vygotsky, paid to the attempts to lay the foundations of psychological investigation into what Vygotsky called "higher motorics."

## THE 1930s AND DEVELOPMENTAL PSYCHOLOGY

Investigation of the complex psychological forms of reorganization of physiological processes, which I termed "psychological physiology" (incidentally, a term I have not previously used in print), made it necessary to study more closely the processes by which behavior becomes organized. In other words, the study of developmental psychology was indicated.

It would be incorrect to conclude, by the way, that this change in the direction of my interests came from the inner logic of my research. The fundamental factor influencing the change was the impact of Vygotsky's ideas. From the end of the 1920s until his death in 1934, I and my colleague A. N. Leont'ev were closely tied to Vygotsky and his work, which for many years defined the course of development of Soviet psychology.

L. S. Vygotsky was born in Gomel in 1896. Having obtained an excellent philological education, Vygotsky wrote a series of works on the psychology of art [which was published only recently (1968)], published his early work, *Pedagogical Psychology* (1926), and in 1924, on my initiative, moved to Moscow. This is when he began his research on a wide number of theoretical problems of general and developmental psychology; it was then that he began his fundamental studies and taught courses. At this time he set forth the directions which became central for Soviet psychology.

Vygotsky decisively discarded the subjective, introspective approach of phenomenological description of the complex conditions of consciousness, typical of the idealistic psychology of that time. Acknowledging the reflex basis of all, even the most complex, psychological processes, he held that any attempt to reduce mental activity to a system of reflexes is incorrect. To believe that mental processes can be reduced to simple reflex acts, he said, means a failure to analyze psychological activity separating those units, each of which retains the quality of the whole, and to break it into elements, which may in the last analysis constitute all psychological processes but which still do not include their specific peculiarities. Such "analysis into elements" would lead to elevation of the observed process to the level of the general—this general level would be characteristic of the psychological as well as the more elementary physiological processes, but would still not reflect the fundamental properties of psychological activity. There is no doubt that water consists of hydrogen and oxygen atoms; however, to think the quality "water" reduces to the qualities of hydrogen and oxygen, losing thereby the peculiarities of the molecule  $H_2O$ , results in excluding from study the special properties of water.

What constitutes a "unit" of the psychological activity of man which retains all its fundamental properties? How are these "units" formed and how do they

function? Is it possible to construct a simple model of a unit that would possess a reflex structure but would acquire new properties characteristic only of the psychological processes of man?

Vygotsky saw such an elementary unit, characteristic of human consciousness, in the process of mediation, which arose in human society because of the use of tools directed at mastery of the environment and the use of signs directed at the control of man's behavior.

Man is not able to exceed the limits of natural laws and by "force of will" move even a single molecule of the external world; he is not able, "by free will," to master his own behavior, inhibiting his reflexes or making himself move his hand so much as a millimeter. He can do all this only in accordance with the objective laws of nature, only having used objectively existing reflex processes, creating from them the means of organizing his own behavior. "*Natura parendo vincitur*"—this is the position presented in Roger Bacon's motto to his early work, *Essays in the History of Behavior* (Vygotsky and Luria, 1930), uniting to this idea another: *Nec manus nuda, nisi intellectus sibi permissus, multum valent. Instrumentis et auxiliis res perficitur.*

How are these "instruments" and "means," which are the characteristic traits of the psychological life of man, created? The study of these concepts occupied so central a place in Vygotsky's work that at one time he proposed to name his system "instrumental psychology."

It is well known that the behavior of animals and man possesses a reflex structure which may be represented by the symbol S-R. However, man not being in a position to overcome his dependence directly may get around it by an indirect mediated path: introducing changes into the external world, man subsequently subordinates himself to the changed conditions he created; acting on nature, man all the same acts on himself; mastering nature, he masters himself. In this act, reflex processes, constituting the essence of the behavior of animals, both remain and change. The S-R scheme is replaced by the more complex  $S_X^R$  scheme. The simple reflex is replaced by a complex reflex system; the application of a tool directed toward the outer world becomes used as a sign directed toward oneself. The determinism of the reflex scheme remains, adding to itself the traits characteristic of complex forms of "voluntary," organized behavior.

Vygotsky's model of these processes robbed the mental world of its "spiritual essence" and made the processes accessible to objective investigation. Moreover, his position forced a rejection of oversimplified methods of investigation. In place of simple stimulus-response methods, which can as easily be used in studies of animals, Vygotsky established another method, which he called the "instrumental method" or the "method of double stimuli." Presenting the subject a certain task (S) he also gave him a certain means or sign (X) by which he could master the task and acquire the appropriate response (R). In accordance with the fundamental model of complex psychological processes, such a method manifested the necessary form ( $S \rightarrow X \rightarrow R$ ), and the objective of investiga-

tion became the way in which the subject forms the auxiliary means (X) and the degree to which he is capable of using it. The study of "significative" activity (which forms and uses signs) became the central task of the objective study of higher mental functions. It underlies the work of Vygotsky, carried out with his young pupil L. S. Sakharov (who died prematurely), which investigated the role of the word or sign in the formation of concepts. This work was published posthumously (1934). It constituted the theoretical foundation of A. N. Leont'ev's *The Development of Memory* (1930), a work which introduced the "method of mediated memory" and which was the first to objectively study the fundamental paths of development of the higher forms of active human memory. The Vygotsky and Sakharov study was the basis for a series of studies of signifying activity using the "pictogram" method (in which a picture serves as a memory aid), which, under the direction of Vygotsky, were conducted by myself and a group of young researchers (A. V. Zaporozhets, L. I. Bozhovich, N. G. Morozova, and others) who later became the nucleus of psychologists working to develop Vygotsky's ideas.

The concepts developed by Vygotsky in the 1920s and 1930s had a double significance. By providing a new approach to the essence of complex psychological processes, his conception provided an escape from the crisis of psychology which, according to him (1927), consisted in the fact that psychology, deterministically approaching the analysis of elementary psychophysiological processes, continued to view the higher psychological functions as a phenomenon of "spiritual life" which could not be explained. The investigators now had a way of approaching the most complex phenomena of mental life, analyzing it in adequate "units" and reproducing in experimental models its most complex forms.

Second, this conception convincingly demonstrated that a scientific approach to the analysis of man's consciousness requires us to discard not only spiritualistic but also naturalistic approaches to mental phenomena, and to seek the kernel of higher forms of psychological activities in social history, in those objective factors which led the most ancient societies of men to the use of tools and to the development of language, which in turn became the most important factors in the formation of man's mental processes. The views of Marx and Engels concerning the social foundations of productive forms of object-activity ("Tätigkeit") and their role in the formation of human consciousness underlay the reorganization of psychology which began to take shape in the work of young Soviet psychologists.

The conception of man's higher mental processes as a product of social development did not remain merely a general theoretical position with Vygotsky and his colleagues. It became the foundation of a series of investigations on developmental psychology which were begun at that time.

If such phenomena of man's social life as voluntary movement and active attention, meaningful memory and abstract thought, are not inherent forms of mental life which can only be described, then should it not be possible to make a

cause-effect analysis of them, to indicate how they are formed and what stages they manifest? The question of "the formation of mental activity" had been posed 50 years previously by Sechenov but it became for Vygotsky and his coworkers the subject of concrete investigation.

Observing the early ontogenesis of the child's behavior, Vygotsky concluded that voluntary direction of one's own behavior is not a product of natural development. Initially guided by the command of an adult, the child moves his hand to the command "Give me the cup" or changes the direction of his gaze in response to the question "Where is the cup?" But at a certain stage the child includes his own directive sign in his speech as a result of which it becomes possible for him to regulate his own behavior. *"Functions which are initially shared by two people tend to become turned upon themselves or shortened and thus become an inner form of the organization of the psychological functions of the individual himself."* In this conversion of interpsychic processes into intrapsychic organization of functions, Vygotsky saw the social genesis of the higher forms of individual mental activity. The investigation of the genesis of higher mental functions and the stages of their further development were the subject of a series of concrete studies of the formation of active attention, mediative memory, abstract thought, and voluntary movement which were developed within a close-knit circle of coworkers and students of Vygotsky, and which later were incorporated into his own works (1934, 1956, 1960) as well as the work of his coworker (Leont'ev, 1959; Zaporozhets, 1960; Gal'perin, 1959; et al.).

These studies made it possible to trace the decisive role of language in the formation of higher mental functions in the child. Language first reflects isolated aspects of the perceived world but then isolates and generalizes fundamental attributes and creates the conceptual forms of the reflection of reality which allow the individual to subordinate his activity not according to surface characteristics but to much deeper connections and relations between the things of the perceived world. These investigations showed that in the process of the child's psychological development not only the structure of mental acts changes but there are also changes in the underlying "interfunctional relations" of mental acts. This is what was meant by changes in the "meaningful and systemic structure of consciousness," the study of which Vygotsky (1960) considered one of the most important tasks of psychological investigation. Finally, in a series of special investigations carried out in the same context, I and my collaborators succeeded in establishing that in the process of psychological development the child not only changes the internal structure of his psychological activity (Luria and Yudovich, 1956) but also experiences a radical reconstruction of the relations among his complex mental functions (Luria, 1936). The latter series of studies, which investigated changes in the relations among mental functions in twins, and which evoked considerable interest in Vygotsky, made a convincing case for the generalization that while in the early stages of mental development the changeability of such factors as memory is in large degree determined by

genotypic factors, in later stages of development the changeability of processes such as memory becomes restructured under the influence of speech, loses its direct tie with the genotype, and begins to depend closely on paratypic factors connected with the influence of the environment. The discovery that in the process of mental development the child substantially changes not only its structure but also, to a certain degree, the *nature* of his psychological functions logically led to that cycle of investigations on the genesis of higher mental processes which was begun by Vygotsky toward the end of the 1920s and beginning of the 1930s, and in large measure defined the interest of Soviet psychologists in the succeeding years.

The position that the most complex psychological processes are a product of social-historical development and that they are connected with mastery of general human experience, the philosophical significance of which has been fully evaluated only recently by A. N. Leont'ev (1959), naturally directed interest toward an analysis of the concrete facts which indicated that the most important psychological factors change their structures in the process of social-historical development. This position also held that the fundamental categories of such psychological processes as the structure of perception, meaningful memory, and abstract thought are a product of historical conditions in the process of which everyday experience is more and more permeated by abstract speech, and that this process produces a decisive influence on the restructuring of the fundamental psychological processes which change not only in their content but also in their structure.

The position of Levi-Bruhl, according to which the qualitative changes in consciousness which are evoked in the processes of social history are connected with a change from magical to realistic thinking, seemed to Vygotsky and his coworkers incorrect from the very beginning. The findings which were derived from the conception discussed above made us think that the process of historical formation of higher psychological functions is completely different. It is necessary to represent qualitative change in consciousness as a change from a concrete form of mental activity, in which the leading role is played by immediate forms of practice, to complex forms of abstracted and generalized types of behavior, generalized forms of knowledge based on language.

These ideas, developed in cooperation with Vygotsky, led me to a whole series of works devoted to concrete manifestation of the historical formation of the fundamental psychological categories. The great strides made under the influence of the rapid economic, social, and cultural transformations were especially noticeable in those years in the Soviet countryside, where there was a rapid transformation from backward to contemporary technology and progressive social relations. These circumstances led us to turn our attention to the question of how, under the influence of social-historical advances, not only the content but the structure of processes such as meaningful perception and abstract thought changed. It was in these years that we collected unique experimental material which permitted us in concrete form to trace the changes

in the structure of psychological processes which occurred under the influence of changing social-historical conditions.

This material, obtained by the writer and a large number of colleagues, indicated the correctness of this conception of historical development of psychological processes. Unfortunately this material was not readied for publication until 1970. It first appeared in a paper in the *International Journal of Psychology* in 1971; a more complete account will be found in my latest book *On the Historical Formation of Cognitive Processes*, published only in 1973.

## THE 1940s AND THE ANALYSIS OF THE BRAIN MECHANISMS OF HIGHER MENTAL FUNCTIONS

While developing the theory of the formation of higher mental processes, Vygotsky, toward the end of the 1920s, began a new line of investigation which more and more began to occupy him and which in the future was to become one of the fundamental spheres of interest of his coworkers.

Studying the structure of higher mental functions, Vygotsky began to turn his attention to an analysis of their brain mechanisms. This enterprise would provide an underpinning for the theory of higher mental functions in the form of a material foundation and thus introduce the new psychology into the circle of the natural science disciplines.

If the higher mental functions are a product of social-historical development, why is it necessary to represent their brain mechanisms in strictly localized and preestablished "cortical centra"? The idea of narrow localization of brain functions, which held that each psychological function possesses its own "brain center" serving as its material substratum, was not acceptable to this new theory. Functions which have their beginnings in the process of prenatal development, which are mediated by the use of language and which represent complex *functional systems*, could not possess as their material base limited groups of nerve cells which fulfill a constant function. The new psychological theory was just as dissatisfied with the equipotentiality theory proposed by Lashley and subscribed to in some degree by the Gestalt psychologists, such as K. Goldstein.

Observations of the behavior of patients with aphasia convinced Vygotsky that disturbances of speech evoke a much wider range of effects on behavior than one would suppose at first glance and that the patient who has lost his central speech mechanisms may suffer substantial disturbances of perception, thought, and the organization of his own behavior. Observations of aphasics during this period gave us a way to view those interfunctional systemic changes which evoked the seemingly specific disturbance of aphasia and which strengthened our belief in the systemic organization of higher mental processes.

At the same time another series of observations began which was destined to become the touchstone for further important investigations. It was in the 1920s

that scientists first began to study diseases such as encephalitis and disturbances of subcortical structures which produce the symptoms of Parkinsonism. Vygotsky made the behavior of Parkinsonian patients the subject of special investigations which led to quite unexpected results.

It is well known that Parkinsonian patients manifest gross disturbances of automatic movements; they may take two to three steps, after which the disturbed tonus of the muscles and the characteristic palsy make further movement impossible. However, the same patient may easily walk up or down stairs and if a number of paper cartons, for example, are strewn on the floor he may easily walk among them without experiencing noticeable difficulties. The stimulation to perform any motor act and the substitution of a series of isolated movements carried out at the cortical level for the subcortical automatism makes it possible to reconstruct the entire functional system and to carry out the given motor act on a new, safe basis.

A focal brain lesion, which leads to aphasia, also leads to disruption of more complexly organized forms of mental activity and often shifts the entire range of behavior toward a more narrow functional level. Lesions of subcortical structures lead to a condition where the elementary forms of motor acts become impossible while at the same time the complex, mediated forms of their organization are maintained. I published observations on the restructuring of functional schemes in both groups of patients (especially Parkinsonian patients) in one of my early works (1932). These observations not only permitted us to determine the basic forms of brain disturbance, but also opened a wide range of possibilities for the systematic, dynamic analysis of complex forms of brain activity in man. It was these investigations which permitted Vygotsky to begin a systemic conception of the work of the brain, which he presented in an address shortly before his death (1934), and to formulate an exceptionally bold hypothesis concerning those changes in the intercentral relations which are manifested by the brain in the latter stages of its development.

This important hypothesis, formulated in Vygotsky's article "Psychology and Localization of Functions" (1934) was published only after his death. (It appeared in the journal *Neuropsychologia* in Vol. 3, 1965.) It can be summarized by saying that if a child has a focal lesion disturbing a certain "center" of the brain which hinders further development of higher overlying formations and thus leads to malfunctioning of a higher, more developed fundamental "center," then a focal lesion in the same "center" in an adult will affect the more elementary functions which depend on it and will lead to the disturbance of centers which lie below it. This hypothesis gave us the first concrete possibility of producing a "chronogenic localization of functions" and opened up new perspectives for the investigation of functional organization of brain activity in the later stages of mental development. One can only regret that the fundamental significance of this hypothesis remains insufficiently valued and that it has not had the influence on the further development of the science of the function of the brain which it deserves.

Investigation of systemic changes of mental functions during aphasia, begun together with Vygotsky and then continued after his death, led me to a closer analysis of the brain function and speech processes and consequently to a more systematic set of clinically oriented psychological investigations. Having obtained additional medical training (which until then had been virtually absent) I undertook a new program of clinical investigations of aphasia in Kharkov at the Ukrainian Psychoneurological Academy and later in Moscow.

Studies conducted at the Neuro-Surgical Clinic carried out at that time with considerable success permitted us to analyze those changes in higher mental functions which occurred as the result of focal brain lesions. Close analysis of verified instances of brain lesions which passed through the Neuro-Surgical treatment indicated the many and complex forms that disturbances in higher mental functions could take. It became possible to approach more analytically the question of the specific cortical mechanisms underlying different forms of speech disturbances. Through investigation of these cortical mechanisms, disturbances of which lead to different forms of speech disturbance, we were able to give a detailed description of the factors underlying the brain organization of speech activity. These studies opened a new, neuropsychological path for analysis of the structure of higher cortical functions.

This work, begun in the second half of the 1930s in the Institute of Neuro-Surgery (later called the Burdenko Institute of Neuro-Surgery), was continued during World War II in a special branch for nervous diseases of the All-Union Institute of Experimental Medicine (later called the Institute of Neurology of the Academy of Medical Sciences) which it fell to me to direct. Occupying more than 30 years, this work culminated in the analysis of two problems which, in equal degree, were of great significance for the development of scientific psychology.

The first of these problems, which is partially described in two unpublished monographs by the author (1940a, 1940b) and comprehensively in the book *Traumatic Aphasia* (1947a; published in English in 1970) was concerned with an analysis of the brain foundations of higher (systemic) mental functions and speech processes in particular. The second problem, dealt with in the book *The Restoration of Functions Following War-caused Trauma of the Brain* (1948; published in English in 1963), was concerned with the closely related problem of the restructuring of higher mental functions disturbed by brain lesions. Both these books, although dealing with neurological material, were further developments of those psychological problems whose investigation was begun by Vygotsky.

The systemic representation of the physiological structure of higher cortical functions found in this work eliminated all kinds of searches for special "centers" in the brain and led us to propose that the higher cortical functions (including speech) are carried out by means of the interactions of complex zones of the cortex, each of which carries more general functions but the ties among which are formed in the process of concrete activity and the mastery of

objective systematic language. This meant that the investigator of the cortical foundations of mental activity and, most of all, of speech processes, had to carefully study the nonspeech functions of the basic zones of the cortex in order then, with a better foundation, to study the role each of these zones plays in the organization of complex speech activity.

Careful study indicated that the separate zones of the cortex which support the work of one or another of the "analyzers" (auditory, visual, tactile, motor) also present certain more general properties. For example, the areas located within the limits of the occipital-parietal area of the cortex may be viewed as the apparatus supporting synthesis of separate (let us suppose successively arriving) stimuli in separate simultaneously (spatial) organized groups. But the areas which are included in the temporal and precentral areas of the cortex carry out a different function, guaranteeing the synthesis of stimuli arriving in sequential (successive) *series*. I. M. Sechenov's idea of two basic types of synthesis, which are of decisive significance for the reflection of the influence of the environment, found its concrete support in this work. Our views concerning the two types of synthetical activity in the cortex formulated during that period and published in a volume on the jubilee of the great physiologist (Grashenkov and Luria, 1945) represented a substantial advance in the understanding of the specific roles of separate zones of the cortex in carrying out higher forms of mental activity.

Conceptualizing the nonspeech functions of the separate zones of the cortex allowed us to separate factors composing the speech processes and to describe the fundamental symptoms characteristic of focal brain lesions. The fundamental symptom of disturbance of the cortex of the left temporal area turned out to be a disturbance in phonematic hearing leading to a disturbance of auditory language codes and to sensory aphasia. The fundamental symptom of a lesion in the parietal-occipital areas of the cortex was found in the disturbance in those complex codes, the fulfillment of which was impossible without simultaneous synthesis. The physiological foundation of such phenomena as the disturbance of operations of grammatical and numerical understanding, which occurred with lesions in the parietal-occipital areas of the left hemisphere, was also explained.

However, analysis of the brain organization of complex mental (and in particular speech) functions was only one side of the investigations occupying the years following World War II. Another, equally important problem was the investigation of how to restore brain functions disturbed as the result of focal lesions. Our studies had indicated that such processes as reading, writing, counting, and other intellectual operations, not to mention speech itself, all of which can be disturbed by focal brain lesions, can also to a certain degree be restored if the investigator finds the unimpaired links in the functional systems which may substitute for the disturbed components. We found that rational use of these methods of substitution may lead to the restoration of processes which had seemed irrevocably lost. These investigations once again convincingly indi-

cated that "higher psychological functions" are in fact complex functional systems\* and made it possible to follow the fundamental stages in their formation. Perhaps the most important attainment of this series of investigations was that they verified our hypothesis that the formation of complex functional systems proceeds "from the outside to the inside." At first the functional system is based on the use of external supporting means and only later, and under certain conditions, does it change over to a restructuring of the inner organization of psychological activity. This method of reconstituting functional systems was successful not only in the restoration of speech but in the restoration of such complex processes as active thinking.

Looking ahead, I continue to consider these experiments on the restructuring of intellectual activity and the restoration of active thought disturbed after injury to the frontal areas of the brain among the most interesting experiments which I have been able to carry out in the many years of work on the study of the brain organization of psychological processes.

Studies of the means by which brain functions disturbed as the result of focal lesions could be restored once again returned investigators to theoretical considerations relevant to the development of higher psychological processes and experimental attempts at their analysis which occupied a central place in the first steps made by Vygotsky and his coworkers. The result of the study of the formation of complex types of psychological activity, especially the study of appropriate "models" for their analysis, later led to that wide circle of studies on the psychological investigation of "programmed mastery of knowledge" which occupied a central place in Soviet psychological science for almost twenty years and which was excellently described in the latest book of my coworker L. S. Tsvetkova, *Rehabilitative Training in Local Brain Lesions* (1972; the English version to be published by Mouton, The Hague).

## THE 1950s AND THE INVESTIGATION OF THE REGULATING FUNCTIONS OF SPEECH

In the preceding section I discussed the investigations of certain brain mechanisms underlying cognitive processes and the organization of speech. These mechanisms constitute an important section of neuropsychology, but still do not include those substantial aspects of man's activity which distinguish it from the activity of other animals and which, in the early stages of the development of Soviet psychological science, were at the center of attention.

We have already indicated that the young Soviet psychologists who worked with Vygotsky in the 1920s were most interested in an objective study of the higher psychological functions of man which were social-historical in their

\*The idea of "functional systems" was broadly elaborated by the outstanding Soviet physiologist P. K. Anokhin.

origin, took place by means of mediated participation of speech as their fundamental structural component, and which were capable of voluntary direction as their functional characteristic. It is natural that the mechanisms of voluntary regulation of higher psychological processes, which were comparatively poorly studied in the investigations just described, should again become the center of attention and that the regulating function of speech, which attracted such great interest in the first decade of the development of Soviet psychology, should again become the center of investigation, but this time on a new level.

The beginning of the 1950s saw in Soviet science an upsurge of interest in the physiological mechanisms of higher nervous processes studied by Pavlov and his coworkers. It was natural that special attention should be devoted to Pavlov's views on the "second signal system" since these not only opened the way for the physiological analysis of speech processes but also coincided with the central problem of the regulating function of speech which was emphasized by Vygotsky. Therefore, the efforts of several Soviet psychologists were directed to a more detailed description of these processes. The problem of the mechanisms by which speech regulates the course of psychological processes came to occupy a leading role in their investigations.

Although the auditory and the motor structure of speech as well as its lexical, grammatic, and syntactic structure had been studied for many years, the regulating influences of speech on the course of behavior—its "pragmatic" side—long remained without attention. Nevertheless, it is exactly through the influence which speech exercises on the formation and course of all psychological processes that one can study the fundamental features of human consciousness. Therefore, there was every reason to assume that the formation of the highest level of human behavior might be tied to the regulating role acquired by speech, and that the origin of a whole series of anomalies of development and pathological conditions might be found in the loss of speech and its regulating influence. We began a series of studies in order to clarify these important questions. With the assistance of several younger colleagues I succeeded in making a series of important findings on the development and pathology of the regulating function of speech, which are described in a number of special publications (1956, 1958, 1959, 1961).

It is well known, for example, that the phonetic side of speech is laid down during the third and fourth years, and that at this time the nominative and semantic functions of speech go through a series of levels of development. But how does the regulating aspect of the child's speech look at these ages?

Experiments carried out by myself and coworkers showed that the speech command of the adult, which is capable of starting the movement of a child 1½ to 2 years old, still cannot establish the stopping of this same movement nor can it create the preparatory program for the completion of a complex movement or overcome the inertia of an act already begun. The 1½- to 2-year-old child who is asked to complete one or another simple task (show a cup, point out a fish, and so on) still is not completely under the control of adult speech; his movement

still continues to be regulated by factors outside the realm of speech, such as immediate perception, the direct orienting reflex, or inert traces of the previous act. Consequently, in cases where, in response to the command "give me the fish," the 1½-year-old child looks at the fish but turns to a brighter, more interesting, or closer chicken, we can conclude that the choice has been evoked by the unmediated orienting reflex, which dominates in the behavior of children of this age. Only gradually, as the child approaches the third year, does the regulating influence of the adult's speech begin to dominate over the non-mediated impressions; the *new functional system*, in which the speech traces strongly lead to the creation of the child's act and attain a dominating significance (1956, 1958, 1959, 1961), begins to form.

What psychological characteristics must the speech of the child have in order to become "the highest regulator" of behavior? It seems natural that the psychological processes underlying speech activity must possess sufficient persistence, concentration, and lability. Without this, speech traces could not be preserved and the speech system could not enter into that flexible connection with the motor system which would be necessary to guarantee its regulating influence. Does the speech system of a young child possess these properties? Do the relations or associations which he has formulated enter into a sufficiently strong connection with the motor acts and attain a strong and flexible regulating influence?

An experimental answer to this question required new experimental methods; these were suggested by E. D. Homskaya (Khomskaya) and were incorporated into a series of investigations devoted to the systematic analysis of the formation of the regulating influence of speech at successive stages of the child's life and in the presence of different forms of anomalous development. Superficially these methods were similar to the "combined motor method" I had used in the 1920s but they were distinguished in a fundamental way from this earlier method.

The child was asked to squeeze a bulb in response to each conditional signal (in more complex experiments, to refrain from pressing during the appearance of another, inhibitory signal). These experiments, carried out together with S. V. Yakovleva and O. K. Tikhomirov (1956, 1958), showed that children 2½ to 3 years old could not fulfill this task with sufficient control: the excitation evoked in the experiment remained too diffuse, and as a result the child, once having pressed on the bulb, was not able to wait quietly for the following signal without giving additional motor reactions during the preintervals.

How can one overcome this initial diffuseness of the stimulating processes? Is it possible to use the child's own speech for this purpose? Has the child reached a stage where his speech can fulfill this role?

For an answer to this question we substituted the child's speech reaction for his motor reaction; when the positive signal appeared he had to say "go!" and when the inhibitory signal appeared he had to say "no!", still not giving any kind of motor reaction. This experiment showed that the speech system of the

2½-year-old still does not possess the needed flexibility, for the speech responses were just as delayed and just as diffuse as the motor reactions. Only toward the third year does the child begin to give speech responses with sufficient rapidity, easily changing over when necessary from positive responses ("go!") to negative responses ("no!").

The observations of S. V. Yakovleva (Luria, 1956, 1958) showed that the diffuse and rigid (according to its neurodynamic specifics) speech of the child 2 to 2½ years old cannot be combined in one functional system with the motor response, and that the child responding "go!" concentrates his whole attention on this response and either does not give the necessary squeeze or gives it after considerable delay, because he is not able to coordinate the two components into one act. It is clear that the development of the child at this stage has not reached a point where we can ascribe a regulating function of speech.

Only toward the third year does this diffuseness and sluggishness of the neurodynamics of the speech process begin to wane; as the experiments of O.K. Tikhomirov have shown, the 3-year-old child makes adequate speech responses quite easily to signals presented to him and even combines his speech responses with motor responses. However, and this is the important point, the combination of speech and motor responses into one synchronous system still does not mean that the speech of the child has completely attained its regulating role and that complex speech mediated functional systems have been formed.

These experiments produced rather striking results. The integration of positive speech responses like "go!" with a motor reaction introduced a certain orderliness into the motor behavior of the child at this stage. Reinforced by the child's own speech commands, the motor responses became faster, they became organized, the indication of superfluous motor excitation and inadequate inter-signal reactions disappear. However, while the excitatory ("impulse") function of the child's speech at this age seemed sufficiently established, the inhibitory function still remained unformed. For upon pronouncing the words "no!" in response to a negative signal, the 3-year-old child simultaneously gave a strengthened motor response which had been disinhibited rather than inhibited by this command. At this stage the child is under the influence, not of the semantic content of the speech command, but its nonmediated "impulse" effect. This separation of regulatory influences into "impulse" and "semantic" dimensions was an important discovery permitting us to describe a new and, up until that time, poorly understood stage in speech development. Only in the 4- to 4½-year-old child does the association of nonmediated ("impulse") and semantic influences of speech appear. The child begins to subordinate his acts to the regulating influence of the semantic aspect of speech; the inner speech of the child begins to develop, there is an accumulation of those functional systems of mediated, linguistic, and psychological processes which constitute the essence of the higher psychological functions of man.

These findings also permitted us to approach from a new point of view important problems of anomalous development and abnormal psychology which had remained intransigent to scientific investigations.

In the clinic, diverse forms of anomalous development and pathological changes in psychological processes had been described repeatedly. Following up these descriptions investigators have sought to identify general laws of pathological deviation and, where possible, to discover the fundamental physiological processes which, it was hoped, would permit the grouping of various pathological conditions and serve as the starting point for their rational classification. Certain Soviet investigators, having studied the features of higher nervous activity accompanying different types of pathological conditions, came to believe that it would be possible to differentiate pathological conditions by an analysis of the characteristic changes in strength, concentration, and lability of the nervous processes and to build, on this basis, a pathophysiology of abnormal behavior. However, such attempts to reduce these pathological conditions to general changes in the excitatory and inhibitory processes inevitably shared those inadequacies of excessive generality which Vygotsky had criticized. This position closes off any possibility of reflecting the real, rich, and many-faceted aspects which distinguish pathological changes in the forms of psychological life.

We took a different approach: would it not be possible, using observations on the formation of higher psychological processes in normal development, to propose a new approach to the analysis of pathological conditions and to express them in units more adequate to their complexity?

The observations on normal development led us to propose that an adequate and rich indicator of the anomalous development of the child or of the pathological condition of psychological processes might be the different forms of the loss of those complex functional systems which are laid down during childhood.

It is well known that among all the forms of anomalous psychological development two can be distinguished as being in many respects the opposites of each other. One is often characterized as an "asthenic" condition which occurs as a result of trauma or some kind of general infection. For the most part it leaves the intellect preserved but results in a weakening of the neural processes which manifests itself in the heightening of excitatory or inhibitory tendencies in the child, in his inappropriate persistence or distractibility as a result of disruption of the lability of fundamental nervous processes. The other form of anomalous development is oligophrenia, in which the intellectual functions are primarily disturbed but underlying which *there is always a gross disturbance of the neurodynamics which is evenly distributed among all types of nervous processes* (Luria, 1956, 1958). Would it be possible using these two "models" to verify the new approach to the psychophysiological analysis of pathological conditions which we had just formulated? Experiments carried out by E. D. Homskaya, E. N. Martsinovskaya, A. I. Meshcheryakov, V. I. Lubovski, and others (Luria, 1956, 1958) provide an answer to this question.

Children with the "cerebral asthenic syndrome" studied by Homskaya (Luria, 1956, 1958-1959, 1961) manifested a gross disturbance of the balance between excitatory and inhibitory processes; however, these pathological features of the neurodynamics, while clearly manifested in their motor reactions,

were much less apparent in their speech processes. It was sufficient to use the method of combining motor and speech processes described above to see that the regulating role of speech remains essentially preserved and that the complex functional systems of activity in which speech controls the flow of psychological processes is disturbed in this case only in a secondary way.

By contrast, in oligophrenic children the pathology of the neurodynamic processes was manifested in the more elementary levels of behavior, but even more markedly in speech activity, giving speech a more sluggish and unstable character. With these children, all attempts to combine speech and movement in a single system preserving the regulative role of speech failed. The experiments objectively indicated the great depth of the loss which had occurred for the complex psychological systems in these children. These forms of pathological condition have thereby received a very clear characterization.

### THE 1960s AND 1970s AND NEUROPSYCHOLOGY

The work carried out in the previous years led to the necessity for the next, synthetic stage in the formation of a new psychological science, neuropsychology. A great deal of my work during the 1960s was devoted to this subject, and this work continues to the present time.

This work included the preparation of a series of publications which generalize the research carried out earlier and with which I hope to make a contribution to a firm foundation to the science of the brain foundations of man's psychological activity, the application of the methods of experimental-psychological investigations to the diagnosis of focal brain lesions, and the restoration of disrupted brain functions. It also includes a series of later investigations of the brain mechanisms of psychological activity which were prepared during the earlier stages of my work. During this entire period, as in the preceding years, my research was closely tied with my work at the faculty of psychology at Moscow University and in the Burdenko Institute of Neurosurgery, where the research was concentrated.

After a long period of investigation, during the 1930s, 1940s, and part of the 1950s I had collected a great deal of material which suggested a general conception of the systemic structure of higher cortical functions, I began to evolve a special neuropsychological method, the "syndrome analysis" of focal brain lesions, which permitted us not only to describe changes in psychological activity produced by focal brain lesions but also made it possible to distinguish the *factors* underlying the disturbance of higher cortical functions in these situations. This approach permitted us to substitute for the disturbed behavior which occurs in focal brain lesions because we had completed an analysis of the mechanisms which underlie the disturbances. At the same time we could approach a series of important questions concerning the internal structure of the

psychological processes themselves. It is easy to understand the importance for general psychology of knowing the role played by separate systems of the brain in the construction of different forms of psychological activity and the factors leading to each of them in the course of concrete psychological processes.

As early as the 1940s I had made attempts to arrive at a general conception of the systemic structure of higher cortical functions and to find a new approach to the analysis of changes in psychological activity resulting from focal brain lesions. In 1947 I published *Traumatic Aphasia* (Luria, 1947a), based on voluminous data collected during World War II; in 1948, *The Restoration of Functions Following War-Caused Trauma of the Brain* appeared; to the same period belongs the paper published jointly with Professor N. I. Grashchenkov, *The Systemic Localization of Functions in the Cerebral Cortex* (1945), which first gave a synopsis of my views on the systemic localization of higher psychological processes and their disturbance due to focal brain lesions.

As a result of new investigations in the 1960s, earlier findings on the disturbances in higher cortical functions caused by bullet wounds were supplemented by a great deal of material on the psychological analysis of behavior changes resulting from brain tumors. Successes in neurosurgery made it possible to obtain clear and verified data concerning localization of functions. Neuropsychological investigation of patients with tumors of the brain, which had as their task more exact topical diagnosis of lesions, was introduced into the neurosurgical clinic. The restoration of psychological processes disturbed as a result of focal brain lesions became an important applied problem. All this made it possible to collect significant material on the psychological analysis of focal brain lesions. The general conception of *neuropsychology*, that new area of science falling on the border between psychology and the neurological clinic, was the result of this activity.

In 1962 the first edition of the author's book *Higher Cortical Functions in Man* (1962; published in English in 1966) appeared, and in 1963 his book *The Human Brain and Psychological Processes* (published in English in 1966). A revised and significantly widened variation of the book *Traumatic Aphasia* was published in English in 1970. Continuing, intensive investigation created the necessity for preparing a second, significantly expanded edition of my basic work *Higher Cortical Functions of Man*, which was published by Moscow University in 1969, translations of which were published in Italian 1964, in German in 1970, and a French translation was begun at the same time as the Russian edition. At the same time a second volume of *The Human Brain and Psychological Processes* was published (Luria, 1970c) in which I discussed the problem of the neuropsychological analysis of conscious activity and which included both theoretical articles and neuropsychological investigations of patients with lesions of the frontal lobes and disturbances of complex forms of conscious activity. At about the same time our laboratory produced a large volume, *The Frontal Cortex and the Regulation of Psychological Processes*,

edited in collaboration with my closest coworker, E. D. Homskaya, and another book, coauthored by L. S. Tsvetkova, *Neuro-psychological Analysis of the Solution of Problems* (1966; published in French in 1967).

Publication of these works permitted me to summarize the fundamental positions concerning neuropsychology as a science and its separate areas. Specific articles devoted to the general principles of neuropsychology include "Factors and Forms of Aphasia" (1964a), "Problems and Facts of Neuro-linguistics" (1967b), "Complex Mechanisms of Psychological Processes" read at the IBRO-UNESCO meetings on the investigation of the brain and man's behavior in Paris in 1968 (1968a), "Neuro-psychology as a Science," which was read at the 16th International Congress of Applied Psychology in Amsterdam in 1968 (1968b), and also "The Origin and Brain Organization of Conscious Activity," being an evening lecture to the 19th International Congress of Applied Psychology in London in 1969. Also, certain most important investigations concerning neuropsychology were two volumes, *Basic Problems of Neuropsychology*, which is being prepared for Harvard University Press, and *Basic Problems of Neurolinguistics*, which will be published by Mouton (The Hague), while a series of works related to the neuropsychological analysis of the functions of the frontal cortex was included in a volume *Behavioral Psychophysiology of the Frontal Lobes*, edited by K. H. Pribram and myself and published by Academic Press. Finally, a comprehensive volume on neuropsychology "The Working Brain" was published by Penguin Psychological Series, Allan Lane, and Basic Books in 1973, and a comprehensive review "Psychological Studies in the USSR" appeared in the Proceedings of the National Academy of Sciences of the USA in 1973.

What is the fundamental position underlying publications identified above and the fundamental lines of work to which it is related? The answer to this question is not too difficult: the scientific investigation, which occupied a lengthy period of time, takes its logic and much of its structure from the work that had already been described in the preceding pages. Important in this regard was Vygotsky's statement of the 1920s that psychology was really divided into two sciences, one of which described the most complex phenomena of the spiritual life of man but refused causal analysis, while a second branch explained the physiological mechanisms of elementary processes excluding from its spheres of interest the complex spheres of conscious activity. Vygotsky saw the way out of this crisis in the creation of a psychological science which studied the origin and laws of the organization of the most complex forms of conscious activity, while not denying the deterministic approach to its causal explanation.

Other Soviet psychologists (A. N. Leont'ev, P. Y. Gal'perin, A. V. Zaporozhets, and D. B. Elkonin) continued the line begun by L. S. Vygotsky, the investigation of the development of psychological processes in ontogenesis and the construction of a theory of psychology beginning with these principles. I took as my task an attempt to develop the same position with relation to the brain mechanisms of complex psychological activity and to develop a path to its neuropsychological analysis. To this task I devoted approximately 40 years of my life.

My approach to neuropsychology can be summarized by saying that the higher psychological processes represent complex functional systems, social in their genesis, mediated in their structure, and carried out by whole complexes of jointly working zones of the brain with certain applications of social ("extra-cerebral") tool and sign using mechanisms. Of the most fundamental importance is the fact that each area of the brain, including the cortex, enters into functional systems in terms of its own *particular role* and makes its own *specific contribution* to the work of the whole functional system. Therefore, disturbance of any of the areas of the brain may lead to a loss of the entire functional system, but each disturbed center excludes a special factor from a given functional system. As a result, brain lesions in different locations affect the system in a different way. It is this fact which permitted us to use the disturbance of the higher psychological processes resulting from focal brain lesions for a topical diagnosis of the locus of the lesion.

In later publications (1968b, 1969, 1973) I described attempts to distinguish three fundamental areas of the brain which necessarily participate in any, even the least complex, psychological activity, each of which exerts a special influence in the organization of psychological processes. The first general part, including the apparatus of the upper brain stem and limbic cortex, was conditionally designated as the area of tonus or the energy area (for the past decade the function of this area has been especially carefully studied in the worldwide physiological literature). The second part, which includes the posterior areas of the cortex (occipital, parietal, temporal), was designated the area for reception, processing, and storage of information. The third part, which includes the frontal cortex, was designated the area for programming, regulation, and control of movements and activity. Detailed analysis of the functions fulfilled by each of these general areas in the organization of psychological activity were the subject of research which I began in the 1930s and which continued for about 40 years.

The role of the brain formations which comprise the structure of the second of the three general areas was the subject of my first period of investigation on this topic, which began even before World War II and continued in the following years. The analysis of the temporal area of the brain and its role in carrying out phonematic hearing, and the analysis of the parietal-occipital areas of the brain and their significance for simultaneous spatial synthesis of incoming information, was reflected in several publications (1940b, 1945a, 1947a, 1948, 1962, 1969, 1970a, 1973a, and others). The disturbance of gnosis and praxis—counting, writing, reading, and complex intellectual operations—which occurs as a result of lesions in these zones permitted us to discover important factors in the organization of these complex psychological activities. I am inclined to consider particularly important the disruption of the role of phonematic hearing in the construction of speech and writing, which was discovered during analysis of instances of focal lesions of the left temporal area, and disturbances of those simultaneous spatial schemes involved in the construction of complex symbolic processes, which were discovered during detailed analysis of parietal-occipital lesions of the left hemisphere.

It was these investigations which permitted me to propose that neuropsychological analysis makes it possible to uncover significant differences in processes which at first glance may seem identical (for instance, musical and phonematic hearing), and to find an inner similarity among processes which at first glance seem to be quite different (for instance, orientation to spatial relationships and certain logical-grammatical structures, the process of counting, and so on). I am certain that future use of neuropsychology for the analysis of the structure of higher psychological processes will turn out to be highly productive in aiding the construction of future scientific psychophysiology (see 1964b, 1967a, 1968b, 1968c, 1970c, 1973a, et al.).

In the 1960s the core of my research and the research of my coworkers has moved from an analysis of areas processing information from sensory input to an analysis of the functions of the *frontal lobes of the brain*. The question of the role of the frontal lobes in the organization of man's behavior had long remained without an adequate solution and investigators had wavered between viewing the frontal lobes as the "higher organ of the brain" and a complete denial of any special function for these areas. The disagreements were in significant measure tied to the fact that the function of the frontal lobes, the latest and highest product of evolution, could not be expressed in the classical terminology of the reflex arc. The absence of any disturbance of sensitivity, or of associative or motor processes, gave some reason to believe that the frontal lobes were a "luxury of nature," whose role in the organization of behavior remained unclear.

Matters changed considerably when people began to apply the conception of self-regulating systems which had developed in recent decades in cybernetics to the organization of behavior. In neurophysiology this movement, among other things, led to a closer investigation of the connection between the frontal lobes and the brain stem formations which support the necessary tonus of the cortex.

Investigations in these directions became the center of attention of physiologists and neuropsychologists of various countries. N. A. Bernstein, in the USSR, put forth the idea of a reflex circle, the mechanisms of which underlie the regulation of motor acts, and studied the organization of motor processes on different neural levels. P. K. Anokhin, one of the leading physiologists in the USSR, proposed the concept of "the acceptor of action," an apparatus which permitted evaluation of the relation between the effect of an act and the initial intention. With good reason he associated the acceptor of action with the functions of the frontal lobes. A very similar position was put forth by K. Pribram, who studied the role of the function of the frontal lobes in the programming and regulation of behavior.

This same theme underlies the work of myself and my coworkers which has been in progress for many years, beginning in the 1930s and continuing almost without interruption up to the present time. It was widely known in the clinic that patients who had suffered massive damage (bullet wounds or brain tumors) in the frontal lobes suffered from a disturbance of voluntary behavior and an

inability to recognize their own difficulties. However, the number of detailed experimental-psychological and physiological investigations of these disturbances was very limited and there was no sufficiently well-based hypothesis concerning the neurophysiological factors underlying the disturbances themselves.

The present context permits only a résumé of the most fundamental results of our investigations on frontal lobe functions, presented not in chronological but in logical order. Using a large number of response measures (plethysmographic and GSR components of the orienting reflex, frequency analysis of the alpha rhythm and its changes, changes in the dynamic waves of asymmetrically increasing and decreasing of the fronts of alpha rhythm potentials, and evoked potentials), E.D. Homskaya and her coworkers (E. Yu. Artem'eva, O. P. Baranovskaya, A. Ioshpa, and E. G. Simernitskaya as well as N. A. Filippycheva) showed that disturbances of the frontal lobe do not eliminate involuntarily evoked indicators of the orienting reflex. In all normal subjects and in all patients with disturbances of the posterior areas of the brain, the presentation of a stimulus with signal significance ("count the signals," "look for changes in the signals," etc.) leads to stabilization of all the orienting response indicators and delays their disappearance which ordinarily occurs as a function of adaptation. The patients with disturbances of the frontal lobes (especially the medial areas of the frontal lobes) manifested a completely different behavior pattern. Experiments showed that *in patients with disturbances of the frontal lobes it was impossible to evoke stable increases in the tonus of the cortex by using speech instructions, and that the stabilization of the vegetative and electrophysiological indicators of the orienting reflex* (which were preserved in patients with disturbances of the rear areas of the brain and which had been established in normal subjects as well) *was completely absent in these patients or appeared in them only in a very reduced and unstable form.*

These findings, which before Homskaya's investigations were unknown in the literature, placed the frontal lobes in a completely special position with respect to other areas of the cortex. As a result of these investigations we can view frontal lobes as an apparatus which participates very directly in the regulation of the tonus of the cortex, so necessary for its alert working condition. It is of particular import that the frontal lobes are connected with lower-lying formations, particularly with the extensive incoming and outgoing signals of the reticular formation, the apparatus guaranteeing the regulation of the conditions of activity which is carried out with the close participation of the speech system. (All these findings are discussed in the recent book of E. D. Homskaya, *Brain and Activation*, Moscow University Press, 1972 as well as in a volume edited by K. H. Pribram and myself, 1973.)

Even our investigations begun in the 1940s had shown that in patients with massive disturbances of the frontal lobes the elementary motor reflexes are preserved; but while there are no manifestations of paresis or paralysis the ability to bring these movements under the control of speech instructions is quite disturbed. These investigations, which were only partially published later (Luria,

1962, 1966, 1969, 1970a, 1973a, etc.) showed that even in the case of simple motor reactions according to speech instructions ("When there is a bell lift your hand") patients with massive disturbances of the frontal lobes can make the response only with great difficulty, and the response turns out to be very unstable. Patients with massive frontal lesions, particularly those with a clearly expressed "frontal syndrome," easily remembered the instruction and were able to repeat it even after a considerable lapse in time; yet after only a few motor responses they would stop performing the task, repeating "Yes, yes, I have to raise my hand!" and not making any movement at all. The regulating function of speech instructions disappeared although the semantic side of the instructions was preserved (A. I. Meshcheryakov). Experiments on *choice reactions* manifested even more clearly the disturbance of the regulating function of speech. Patients in this group readily learned the instruction "In response to a red light press the right key, in response to a green light press the left key" or "In response to one tap lift your right hand, in response to two taps lift your left hand" and could easily repeat such an instruction. However, it was necessary only to change the stereotyped order of presenting the signals for the performance of the given program to be disturbed; the patient would repeat the previous action, complete the alternating movement of the hand regardless of which signal was given to him, or continue to respond to any signal with one and the same hand (M. P. Ivanova).

These defects appear with particular clarity in those situations where the action of an immediately perceived signal is in conflict with its conditional significance (for instance, when the patient is asked to respond to one signal by making two responses and to two signals with one response, or to answer to a long signal quickly and to a rapid signal with a slow movement). Experiments carried out under these conditions by Homskaya and M. Maruszevskii (Luria and Homskaya, 1966) showed that patients with massive disturbances of the frontal lobes very quickly stopped regulating their movements to the speech instructions and instead responded with elementary echopractic repetition of the signal.

It is easy to see that disturbances of the regulating function of speech caused by disturbances of the frontal lobes destroy those functional systems which, as our early experiments showed, are formed in the 3- to 4-year-old child during the period of maximal growth of the frontal lobe system, and the loss of which may be observed clearly only in the clinic, where disturbances of these areas of the brain are treated.

Analysis of the disturbance of behavior during massive disruption of the frontal lobes has not been restricted to these relatively simple forms of motor reactions. In the 1940s we had carried out investigations showing that frontal lobe patients lost the ability to independently formulate plans and programs of complex constructive activity. This was shown initially in the work of S. G. Gadzhiev (Luria and Homskaya, 1966) with Link Cube and then in the work of L. S. Tsvetkova (Luria and Homskaya, 1966) with Koh's blocks. In both instances patients were clearly unable to construct a plan of action, and their behavior was sharply distinguishable from that of patients with disruption of the

posterior (parieto-occipital) areas of the brain, who manifested the optical-spatial defects characteristic of these disruptions.

Similar findings were obtained during a detailed analysis of the perceptual capability of patients with disturbances of the frontal lobes. They showed clear defects in the perceptual orienting-investigatory activity, which allows man to collect the information he needs and which makes meaningful perception an active, directed process. These data were obtained in my laboratory by O. K. Tikhomirov (Luria and Homskaya, 1964) and were closely studied in experiments which recorded eye movements during the perception of complex pictures (V. A. Karpov, A. R. Luria, and A. L. Yarbuss, 1968).

This cycle of experiments was completed by investigations of changes which occur in frontal lobe patients in respect to complicated forms of cognitive activity—for example, understanding complex oral fragments and solving problems. In these experiments carried out by Tsvetkova and myself (Luria and Homskaya, 1966; Luria and Tsvetkova, 1966), we clearly showed how the frontal lobes play an important role in the regulation of such complex intellectual processes. The experiments permitted us to contrast the insufficiently convincing and overgeneralized notions concerning disturbance of “abstract sets” with a significantly more reliable conception of the role of the frontal lobes in the programming, regulation, and control of psychological activity.

As in much of our work, the research on frontal lobe functions has been concerned with the application of neuropsychology to the restoration of functions disturbed as the result of focal brain lesions. Our experience during the war, when I and my coworkers found it necessary to work in neurosurgical hospitals specializing in restoration, permitted us to formulate theoretical assumptions concerning the restoration of brain functions after war trauma (Luria, 1948). In the course of later years my principles were verified and extended in a series of studies on the programming of restorative training, the basis of which was developed in collaboration with Tsvetkova (1964) and summarized in the latest book of L. S. Tsvetkova, *Re-habilitative Training in Local Brain Lesions* (1972).

I have dwelt in detail on those aspects of neuropsychology which were developed in the course of many years and have a relatively completed character. I shall only briefly mention one area of this large section of psychology which is the subject of current investigation and whose completion is a matter of the future. This concerns the role played in the organization of complex forms of psychological activity by the deep structures of the brain, in particular those sections which enter into the structure of the first of the three “fundamental areas” which I noted above and which support the tonus and activation level of the cortex.

The whole history of science of recent decades shows the great attention that has been given by physiologists to the detailed study of the functions of the brain stem, the reticular formation, and limbic areas. As a consequence it is

completely indefensible to continue not paying attention to the vertical organization of the brain apparatus. Therefore, I have been faced with the question: What significance do these deep structures of the brain have for the structure of the higher forms of psychological activity of man?

Investigation of patients with lesions of the upper area of the brain stem (the hypothalamic and thalamic areas and the limbic system) using the usual methods for the study of gnosis, praxis, speech, and thinking, produced no substantial results; consequently, I was forced to search for new ways to evaluate the contributions which these brain formations make in complex forms of psychological activity. Various attempts carried out in the course of several years led to substantial results, indicating the path for future investigations. It turns out that lesions of the deep structures, along with disturbing the general tonus of the cortex, lead to substantial disruption of *memory*, as many leading investigators have pointed out, and this fact led me and my coworkers to devote recent years to the study of the nature of the changes in memory which are produced by such lesions.

In 1967 I published the results of a study carried out jointly with E. D. Homskey, S. M. Blinkov, and MacDonald Critchley on a patient with a tumor in the medial area of the frontal lobe. These observations showed that lesions of these areas of the brain do not lead to much noticeable disturbance of gnosis, praxis, and speech but do evoke lowered cortical tonus, a condition which makes careful selective psychological processes impossible; old and irrelevant ties begin, under these conditions, to disturb behavior and to occur as readily as the substantial and needed ties. This change in the selective structure of the psychological processes turns out to be characteristic for patients in this group.

Further investigations have verified that this was the proper way to view the role of the deep brain formation in the flow of complex forms of psychological activity. It turned out that whenever there was a lesion of the upper brain stem and its ties with the limbic cortex (including the hippocampus), there was an increase in the extent to which interfering factors inhibited traces. It is because of this phenomenon that the primary disturbance of memory, which is characteristic for this type of brain pathology, occurs. It was also found that disturbances of memory such as appear in these cases do not manifest any modal specificity, appearing alike in all types of activity (visual, auditory, motor, speech). Finally, we found that while a limited lesion of the upper brain stem might appear symptomatically only as increased inhibition of the traces, in cases of massive disturbances in this area (a tumor of the deep structures, distributed along the midline) there was not only the heightened inhibition of traces but also the disturbances of selectivity which we noted above and which apparently evoke the phenomenon of "equality of excitation of traces" characteristic for weakly functioning cortices. When, along with the disturbances of this zone, there are lesions leading to a dysfunction of the medial areas of the frontal cortex (as the result of a tumor or arterial spasms), the symptoms are manifested in a particularly sharp form and neuropsychology is in a position to study the

mechanisms underlying the altered conditions of consciousness and the confusions which are components of Korsakow's syndrome. These findings are published in a series of works of my collaborators (L. T. Popova, M. Klimkowski, N. K. Kyascenko, Pham Ming Hac, and N. A. Akbarova) and in a monograph by A. R. Luria, A. N. Kononov, and A. Ya. Podgornaya (1970), in a forthcoming book by N. K. Kyascenko, L. Moskovichute, T. O. Faller, et al., and in my two-volume monographs *Neuropsychology of Memory* (in press). They show that neuropsychological analysis may be productive in evaluating the contributions which the deep structures of the brain make in the flow of complex forms of higher psychological activity. In addition, they open up new perspectives for analysis of the inner mechanisms of activation and consciousness which, until now, have not been accessible.

The neuropsychological analysis of memory disturbances was only one topic of my work during the early 1970s. The second was a series of research leading to a new branch of science—that of *neurolinguistics*.

The analysis of basic cortical processes underlying language and speech was the starting point of our early studies of aphasia, which started in the 1930s, which was summarized in the volume *Traumatic Aphasia* in 1947, and which was followed by a series of special papers on aphasia. That brought me to the necessity to return to the basic problems of language disorders and the description of the cortical organization of speech from a new standpoint.

During the last two decades significant changes in linguistic sciences occurred and a new branch of science, psycholinguistics, was created. A series of outstanding authors turned to the description of basic problems of phonemic and lexical, syntactical, and semantic descriptions of linguistic structures. It became impossible to ignore these achievements and to continue the study of language disorders without a good knowledge of this new and important branch of science.

That is why starting from the late 1960s and during the early 1970s we returned anew to the problems of aphasia, trying to reconsider our former concepts of language disorders in local brain lesions. We started a revision of the problems of verbal communication, of basic laws of encoding and decoding of verbal processes, and we came to a reconsideration of the basic forms of aphasic syndromes. We had to try to formulate some new concepts of the psychophysiological mechanisms of speech disorders, and to formulate once more our concepts of aphasia, adding some important considerations to the revision of the concepts of complex forms of aphasia—"conduction aphasia," "transcortical aphasia," and "amnesic aphasia." The result of these observations were given in a series of papers such as "Factors and forms of aphasia" (1964), "Problems and facts of neurolinguistics" (1967), "Aphasia reconsidered" (1971), "On two basic forms of aphasia" (1973), and so forth. New vistas in neuropsychological analysis of the processes of verbal communication became clear, and I felt a necessity to summarize these new approaches in a volume *Basic Problems of Neurolinguistics*, which was ready toward the end of 1973 and which had to be published

in Russian and English as one of my last books. To come to this decision I had both to study very carefully the most important achievements of modern linguistics and to reconsider my former approaches to the disturbances of speech and language in local brain lesions. I still have the feeling that this step of my work will be of a significance for the developing of this new branch of science and that together with my coworkers and friends I could contribute to this new step in the development of our knowledge.

Neuropsychological investigations, which have been a large part of my scientific life, have helped to clarify one position with which I would like to conclude these pages.

The study of the phenomena under consideration began with a "complex syndrome" investigation of psychological processes and convinced me of the productivity of that path, which unfortunately is still not part of contemporary psychology.

It is well known that the psychologist always concentrates his investigation on one or another interesting process, constructs hypotheses, and develops adequate methods for the investigation of this process. The reliability of the data he obtains is demonstrated by statistical analysis and replication. Lack of attention to the remaining processes of psychological life, and the narrowing of his interest to the study of the single process he has decided to focus on, represents a necessary condition for the logic of his investigation.

A completely different logic characterizes clinical (including neuropsychological) investigations. The neuropsychologist, studying the role which one or another system of the brain plays in the flow of complex psychological processes, finds himself in quite a different situation. As a rule the number of cases (patients) with focal brain lesions on whom he can investigate his hypotheses is very limited, and the reliability obtained as a result of the investigation cannot be determined by statistical methods. As a result the neuropsychologist must choose another method. This method is widely used in clinical studies under the name "syndrome analysis." Its essence, well formulated by the leading neurologist Kurt Goldstein, consists in the following. The investigator chooses a fundamental symptom which usually appears following a focal brain lesion and then hypothesizes some factor the inclusion of which must have led to the manifestation of this syndrome (for instance, disturbances of simultaneous spatial synthesis resulting from lesions of the parietal-occipital lobes of the brain, disturbances of successive motor synthesis resulting from lesions of the premotor area of the brain, etc.). In order to verify the correctness of this hypothesis, the investigator turns to a detailed analysis of other psychological processes the study of which is not a primary part of his task. These should be psychological processes which are included in his "factor" as being the result of a focal brain lesion and which must necessarily manifest themselves in the form of a disturbance. The opposite is also required:

psychological processes which do not enter into this factor must remain intact. As a result of such an analysis one obtains a whole complex of interrelated symptoms or "a syndrome," and the more correlated attributes it includes, the more certain we are of our hypothesis.

The method of "syndrome analysis," which is the fundamental method of neuropsychology, permits one to carry out a unique kind of "factor analysis" on one individual and has established itself as a general method for clinical psychology. However, its significance extends far beyond the confines of the clinic. It is one of the most promising methods for one of the most difficult areas of general psychology—the *psychology of personality*, which usually is of a descriptive character.

I have attempted to apply such a "syndrome analysis" to an instance of extraordinary memory, published in a small book *The Mind of a Mnemonist* (1968d). In this book I attempted to analyze the structure of the personality of a man who possessed an exceptional (in practice, unlimited) synesthetic memory. I concentrated not so much on the special features of his memory as on the consequences that this extraordinary memory had for the structure of the entire personality. I followed the same way in another book, where a single person with a lesion of the parieto-occipital part of the brain and a disturbance of spatial relations and complex memory was studied. It appeared in Russian in 1971 under the title *The World Lost and Re-gained* and in English in 1972 under the title *A Man with a Shattered World* (Luria, 1972c).

I would hope that this initial attempt would represent a small "kick-off" which may initiate neuropsychological investigations relevant to the exploration of important problems of psychology as a whole.

## UNSOLVED PROBLEMS AND PERSPECTIVES

This summary of the path I have followed over a span of almost 50 years of work has of necessity been long. Certain thoughts concerning the problems which remain unsolved and *future perspectives* can of course be significantly shorter. This is understandable because it is natural to think that a summary of the past is based on much richer information than are glimpses of the future, and because the time which remains for me for future work is incomparably shorter than the time already spent in traveling the path I have described.

As often happens with investigators when they are contemplating unsolved problems, I experience real feelings of dissatisfaction and I well understand the extent to which the "mountain of the unknown" is greater than the small bit that is already known. But as always occurs in such instances, I try to take comfort from the thought that the little bit which each man may accomplish, especially in cases where the man is of moderate talents, is only a component part of the work of a group as well as of that system of studies carried out in a given

area of science. This thought can serve as support for the idea that this chapter from *A History of Psychology in Autobiography* should be concluded with some reflections about the perspectives of future research.

In all my work, which basically has been devoted to the development and loss of higher cortical functions and the neuropsychological analysis of brain functions in man, I have consciously assumed the validity of three kinds of abstractions. We abstracted the phenomena we studied from the whole of the rich material of the clinic; we did not go into the neurodynamic analysis of pathophysiological data; we were too isolated from some neighbor fields of science, especially from the progress of modern linguistics; finally, we abstracted the psychological processes that we have studied from a probabilistic matrix of events.

This tripartite abstraction, which is inescapable at our level of development, will not be permissible in the future. Before us lies the holistic task of going beyond the limits of those schemes which have guided our work up to now and which, although they are correct as basic models, are inadequate for a closer analysis of the entire range of phenomena.

There is little that I can add in the way of describing the basic functions of the separate systems of the brain of man, particularly with respect to the frontal lobes, which were the primary subject of our analysis. However, the richness of these functions and the differences among them are so great (as are the effects of different lesions) that what actually occurs goes far beyond what I have been able to describe here.

Close analysis has shown that none of the fundamental areas of the cortex, least of all the frontal lobes, represents a unitary whole. Clinical experience convinces us that lesions of the basal, medial, prefrontal, and frontal lobes, as well as lesions of the right and left hemispheres, all lead to completely different syndromes, and that the underlying function of each of these areas is apparently different. The same can be said for the different brain systems. If we add that lesions of each of these systems take place under different subcortical and cortical conditions, and that the psychological significance relating to the areas of the left (dominant) and right (subdominant) hemispheres is quite different as between the two, we can see that neuropsychological investigation faces a huge task. I have undertaken only the first steps in such work by having begun, together with my closest coworker E. K. Homskaya, to think about the "varieties of the frontal syndrome," and with other coworkers (in particular E. G. Simernitskaya, T. O. Faller, N. K. Kyascenko, et al.) to discuss the problem of the neuropsychological analysis of deep lesions of the brain and the syndromes of lesions of the right hemisphere. And if, which is more than probable, I am unable to significantly progress on this problem, others will certainly do so.

In previous years we consciously neglected to make a physiological (neurodynamic) analysis of the phenomena we observed. Now such neglect is becoming a hindrance for future work. It is well known that a pathological focus

not only disturbs one or another factor in a given part of the brain; it changes the normal course of neural processes and the change represents sometimes general and sometimes specific effects.

Now we are beginning to find out that pathological changes in the cortex change tonus and disturb the normal "law of strength" according to which the strength of a response is a linear function of the strength of the stimulus (or stimulus trace). It is well known, also, that the pathological changes caused by a brain lesion change the lability of neural processes and thus lead to a condition wherein the evoked system of excitation acquires a pathologically inert character which must necessarily influence the normal course of psychological activity.

Before us lies the task of reviewing the facts established earlier and of passing their analysis through the prism of the laws of pathological change of neurodynamics. It is hardly necessary to state that this work, which has become central to the future progress of neuropsychology, will require years and will have to be the fundamental concern of future investigators.

In the flow of the last decades when I was busy with the construction of basic concepts of neuropsychology, I was very separated from the significant achievements of a series of neighbor sciences and, first of all, from modern linguistics and psycholinguistics. That branch of science made a tremendous success during the last decades, and it would be unwise to ignore the progress of this field. That is why a necessity arose—to incorporate the richness of new ideas of linguistics and psycholinguistics in our knowledge, to construct some new approaches to the problem of verbal communication and speech pathology which would include new concepts of linguistics as well as new neurodynamic approaches toward the brain mechanisms of language. That required a construction of a new field—that of *neurolinguistics*, and a revision of basic approaches to aphasia.

It is easy to understand that this became one of the most powerful motives of my work during the last years; the results of this work were reflected in a series of my latest publication on aphasia and will be reviewed in my next book, *Basic Problems of Neurolinguistics*, which will appear in 1974 in the Moscow University Press and the English version in Mouton (The Hague).

In the course of many years I have investigated the formation and disturbance of psychological processes, the structure of which was accepted in contemporary psychology, and more or less ignored the probabilistic structure of these processes. This abstraction, which was unavoidable at that level of research, limits the perspectives of future research.

Investigations carried out by many researchers convincingly demonstrate that such processes as recall of words and decision making can never be reduced to a simple linear association between the sound and the significance, or the intention and the movement, as was accepted previously. Now it is quite clear that all these processes possess a probabilistic character such that when a word is remembered, or a solution is chosen from among a set of alternatives, and either

of these processes occurs with differing probabilities, then both the choice of the word and the final problem solution are the result of a choice among alternatives.

These conceptions of the structure of any complex psychological process must be used in psychological investigations. Problem solving is based on an organized and selective flow of higher nervous processes, and whether the pathological focus changes the normal condition of the cortex only within the limit of a single system or throughout the entire brain, the organized process of "problem solving" may be substantially disturbed. An approach from this point of view to the phenomena of agnosia or apraxia, of disturbed speech or conscious activity, would uncover a much deeper set of intimate mechanisms related to the flow of psychological processes than does the idea of a linear succession of phenomena which underlie many of our earlier studies. This leads me to think that analysis of the course of normal and pathologically changed psychological processes which evaluates the probabilistic nature of their structure will throw substantially new light on the data collected in previous investigations.

It is obvious that a rational statistical approach to all these phenomena has to be elaborated; but it is clear as well that the existing mathematical apparatus for elaboration of the reliability of the symptoms we describe in patients with local brain lesions is insufficient, and that a new mathematical apparatus adjusted for a syndrome analysis in a relatively small number of cases has to be elaborated. We tried to express some ideas concerning such an apparatus in my paper with E. Yu. Artemieva (1971), and we hope to continue this search.

And here I find myself convinced that the facts already obtained by our own research must be reviewed from this new viewpoint, and that a new perspective will thus be afforded for the reconstruction of the research carried out earlier. There is no doubt that this reconstruction, toward which I have only begun to move, will occupy many years and will be substantially advanced only by future investigators. A life lived in the context of scientific search is, after all, very short, and each investigator who travels a seemingly long path must have the willingness to conclude a retrospective review of his work by indicating the perspective which will be followed without his participation.

But I began these notes with the thought that while people come and go, the solid work remains, and that the work which has been accomplished through the efforts of the individual investigator will be continued in the future by virtue of its own internal logic. I can only hope that this will be the result in my own case.

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