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A.R. Luria's Contribution to the Study of the Brain Organization of Language

A.R. Luria is one of the most prestigious scientists in neuroscience, neuropsychology in particular. His contribution to aphasiology and neurolinguistics is well known. However, today some researchers believe that A.R. Luria's main ideas have lost their relevance and have little influence on contemporary discussions.

The paper presents the views of A.R. Luria on the brain organization of speech and aphasia. Although he developed his concept of the relationship between cognitive processes and brain work several decades ago, scientific and technological achievements in our days largely confirm many of his ideas and hypotheses. A.R. Luria's basic views of the brain and language are considered in this article in the light of modern neuroscience. Two main monographs and some works of A.R. Luria, which are dedicated to the brain organization of speech and to the classification of aphasia, are analyzed. In particular, comparisons are made between his initial assumptions about aphasia and their theoretical rationale in the book «Traumatic Aphasia» (1947) and his more complex interpretation of the cerebral organization of speech, which is presented in his work «Basic Problems of Neurolinguistics» (1975). The paper discusses differences between these two books and also linguistic issues, which received much attention in his later publication. It considers the concepts of functional systems, systemic and dynamic organization of speech, proposed by A.R. Luria. It is shown that his interpretation of the cerebral organization of speech as a specific contribution of various brain regions to the speech system continues to be widely used, and his significant contribution to neurolinguistics is widely recognized.

Many ideas of A.R. Luria have been integrated into contemporary aphasiology, while some questions of his proposed classification of aphasia remain debatable.

Keywords: *A.R. Luria; aphasia; neurolinguistics; brain organization of language; cognitive neurology.*

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Introduction

Alexander Romanovich Luria (1902–1977) represents one of the major and most influential authors in cognitive neurosciences, particularly in neuropsychology, during the 20th century [3]. Indeed, he is frequently regarded as the founder of contemporary neuropsychology [4, 5]. His papers, book chapters, and books continue to be published worldwide, analyzing, discussing, and advancing his ideas [6, 7, 8].

Although Luria's interpretation of human cognition was proposed several decades ago [1–2, 9–14], new scientific and technological advances have significantly supported many of his ideas and hypotheses. In this paper Luria's major ideas about brain organization for language and aphasia will be examined in the light of contemporary neurosciences.

Luria`s interpretation of brain organization of language and aphasia:Comparison of initial and final proposals

Luria published two major books on brain organization of language and aphasia. The first, «Traumatic Aphasia», initially published in Russian in 1947, was followed up with a revised, English publication in 1970. Indeed, his initial studies of aphasia began in 1929. In 1940, Luria was preparing three volumes devoted to sensory, semantic, and motor aphasias. The first volume on sensory aphasia formed the basis of dissertation defended for the degree of Doctor ofMedicine in 1943 (the dissertation for the degree of Doctor of Psychology was defended in 1936). The second volume on semantic aphasia was written, but not completed[1]. Materials for the third volume were prepared and partly published in 1963. In August 1943 Luria finished «Essays on theory of traumatic aphasias»[2]. After the war «Traumatic aphasia» was published [16].

Almost 30 years later towards the end of his life, Luria published «Basic Problems of Neurolinguistics» [2] in which he presented a more elaborate interpretation of the brain organization for language in normal and abnormal conditions. Between these two dates, he published numerous papers directly or indirectly related to the topic of language and aphasia [2, 17–27]. As a matter of fact, in the 20th century, Luria is regarded as the most expe-

[1]The typescript in 219 pages is kept in Luria's family archive. The content of the book is discussed in Akhutina & Agris [15].

[2]The typescript in 138 pages is in Luria's MoscowStateUniversity archive.

rienced researcher with regard to aphasia [28]. His interpretation and classification of aphasia is still widely used, particularly in Eastern Europe and Latin America.

Brain organization of language: Initial proposal (Luria, «Traumatic aphasia», 1947/1970 [1])

Several important proposals and ideas are presented in this book. We shall specifically refer to: (a) Luria's interpretation of aphasia; (b) his classification of aphasia; and (c) his attempt to establish clinical/anatomical correlation using the method of superimposing the lesion drawings.

Luria's interpretation of aphasia

To go beyond pure phenomenological description of aphasia, Luria proposed to distinguish andidentify the defects that underlie its different forms. On the basis of his empirical analysis of the frequency and severity of aphasic syndromes, Luria divided speech areas into two groups: «primary speech areas» associated with severe forms of aphasia and «marginal areas» causing mild forms of aphasia when damaged.

Luria wrote that speech areas developed out of previously existing motor and sensory areas. «With the historical evolution of language, they underwent some modification, and their coordination with one another created the cortical functional systems which subsequently became the 'basic speech areas'»[1, pp. 102P103]. Luria attempted to understand complex aphasic syndromes by studying the partial disturbances which arise with lesions limited to the marginal areas. «These lesions give us the opportunity to identify the different physiological components of more complex aphasic syndromes» [1, p. 102]. It is worth mentioning that these ideas of Luria trend closely to that of «embodied cognition» (the theory proposing that many features of cognition are shaped by aspects of the entire body of the organism, including the motor system and the perceptual system) in today's neurocognitive science[29-32].

To explain how he approached understanding the brain organization for psychological processes, Luria wrote a special theoretical introduction for the English version of «Traumatic aphasia». Here he criticized both the «localizationist» point of view proposed by most authors since Broca, and maintained during the late 19th and early 20th century. Similarly, he criticized the «holistic» position presented by different authors, including Kurt Goldstein and other representatives of «noetic school». Luria concluded that the fundamental position that should be taken in a scientific theory about the normal and abnormal brain organization of cognitive processes is the point of view that psychological processes are highly differentiated «functional systems». Instead of considering some «centers» for complex psychological processes, he introduced the concept of dynamic structures or constellations of brain areas. He suggested that each area contains a segment of a functional system, having a particular function, and participating in one or another type of cognitive activity. When offering these ideas, Luria followed the theoretical positions of his friend and mentor Lev Vygotsky and the Russian physiologist Peter Anokhin. Vygotsky had proposed the concept of «psychological system» to describe «higher psychological processes» [33,34]; Anokhin in 1935 introduced the concept of «functional system» as a «model to describe the structure of brain organization of behavior» [1, p.87].

Following Vygotsky's interpretations [33,34], Luria considered that all higher mental functions «have a social genesis, a systemic structure, a dynamic development» [35, p. 390). Accordingly, language is a «complex functional system» requiring many different operations to achieve both comprehension and production, so simultaneous participation of multiple cortical areas is required for normal language processing. Each cortical area accomplishes a specific process, but it also participates in different functional systems.

Luria considered «syndrome analysis» as a fundamental approach in aphasia analysis: based on systemic structure of language (as any other higher mental functions); «syndrome analysis» for Luria implies to identify the primarily impaired component (primary defect), the secondary systemic consequences of the primary defect, and tertiary compensatory reorganizations. Not only disturbed elements, but also preserved language elements have to be considered in each particular patient. The most important thing is to disclose a particular component that has been impaired in language processing (or «factor» underlying each type of language disturbance. «Factor» is understood as a structural-functional unit [36,37]. Luria understood the term syndrome as it was traditionally interpreted, a group of signs and symptoms that occur together and characterize a particular abnormality or condition.

Classification of aphasias

Following these ideas, Luria considers different brain zones as being responsible for different operations of verbal activity. Different components of language may be impaired in cases of different localized brain pathologies

Luria distinguished six different types of aphasia, three of a sensory/understanding type and three of a motor/production type. Each one of these forms of aphasia is related to impairment at a specific level of a language functional system (see Figure 1).

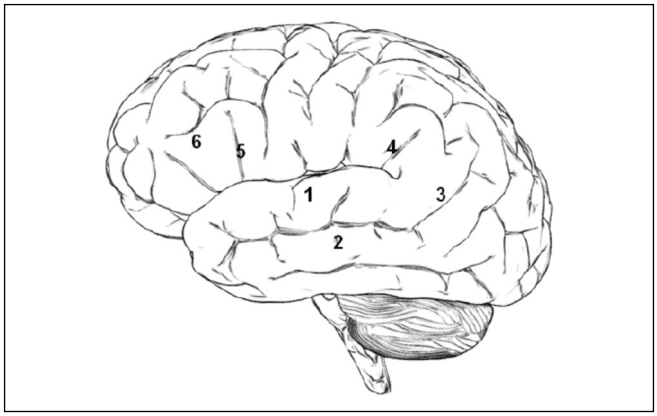

Figure 1. *According to Luria, language is a complex functional system including different operations related to functions of different brain zones: (1) phonemic discrimination; (2) verbal-acoustic memory; (3) understanding of grammar constructions and word-retrieval; (4) articuleme selection; (5) kinetic organization of speech and grammar structuring; (6) verbal planning. Diverse language impairments are associated with lesions of these areas in left hemisphere.*
Note. *For a detailed review of the characteristics of each type of aphasia, see Akhutina [38].*

Disorders of language reception

Different levels of language understanding can be identified. The first level is represented by the recognition of language phonemes. It is known that the superior temporal gyrus (Brodmann area 22) of the left hemisphere, as well as the primary auditory cortex BA41 and BA42, play a crucial role in the discrimination of the phonemes [39]. It has been well established in clinical neuropsychology that damage in these areas results in a deficit in language understanding. Luria has explained this as problems in discriminating the phonemes of the language. This area corresponds to Wernicke's area [40] and Luria named this disturbance in phoneme recognition as sensory or acoustic-gnostic aphasia, implying that it is a perceptual recognition defect (agnosia) for the language sounds (phonemes).

Word recognition represents a further step in language understanding. Disturbances in word recognition are observed in cases of pathology of the middle temporal gyrus (BA21) [41]. labels these disturbances as acoustic-mnestic aphasia [1]. The patient can discriminate the phonemes included in a word, but cannot recognize that such a sequence of phonemes corresponds to a language word. It is a disturbance at the level of vocabulary (lexicon).

The following step in language understanding is represented by the comprehension of the meaning of the word. In normal conditions word recognition is automatically connected with the actualization of word meaning, or more precisely, referential meaning. In patients with acoustic-mnestic aphasia, this process is disturbed [42].

However, the comprehension of the meaning of the word could be impaired by another reason in cases of so-called semantic aphasia. Following Vygotsky [34], Luria distinguished «referential meaning» (the connection between a word and an image of object) and «categorical», or «significative meaning» (the connections inside the hierarchical system of meanings). Patients with semantic aphasia (with lesions situated in the temporal-parietal-occipital areas of the left hemisphere) have no acoustic-gnostic or acoustic-mnestic problems and they still have difficulties of word comprehension and naming. Luria wrote: «The primary image represented by a word, i.e., its specific «relatedness to an object» remains intact. But the system of relationships centered about the word is profoundly impaired» [1, p. 228]; see also Akhutina, chapter 14 and 15 [42]. These patients have the tendency to forget the names of objects and make so-called semantic paraphasias (i.e., semantic substitutions; for instance, the word «chair» is substituted by «table», «sofa», and the word «crocodile» by «camel», «lizard»).

However, word understanding is not the last step for language understanding. Sentence understanding represents the following step. Two different types of sentence content can be distinguished: «communication of events» (The boy is reading a book) and «communication of relations» (father's brother). The first one reflects the visual situation that is transmitted by a sequence of words naming the situation details. In the second case, words do not reflect different details of the situation. Instead, they convey a certain relationship to each other, and the meanings of words form a quasi-spatial simultaneous unity.

The understanding of sentences and phrases with the «communication of relations» is impaired in cases of left parietal-occipital pathology. Such «receptive agrammatism» includes understanding not only constructions like «father's brother» but also sentences with time adverbs (such as before, after), space adverbs (such above, below), comparative adverbs (such as more, less) as well as inverted (for example, passive) constructions (such as Pete is beaten by Ivan). The primary difficulty lies in «the unification of individual elements into a single simultaneously-beheld system» [1, p. 230]. The described receptive agrammatism is a part of the syndrome named by Head [43] as semantic aphasia.

Disorders of expressive language

Different levels of language production can be separated. Language articulation represents the most basic level. First, articulation requires the ability to correctly use the articulatory system and depends on the lower areas of the post-central (kinesthetic) parietal lobe. Damage in this area results in a disturbance in the articulatory unit or «articuleme», i.e. specific articulatory pattern required to produce a sound. Patients have difficulty distinguishing close articulations and express a significant amount of phonological errors (phonological paraphasias). Luria describes this type of language disturbance as «afferent» or «kinesthetic motor aphasia». The syndrome of afferent motor aphasia frequently has been equated with conduction aphasia. As it is well known, the major characteristic of conduction aphasia refers to a disturbance in language repetition; sometimes it is impossible to produce the word during repetition, but not in spontaneous and conversational language. Luria, however, points out that language repetition defects can be found in different types of aphasia; a point of view that has been corroborated [44]. Afferent motor aphasia is usually associated with positional apraxia and oral apraxia and can be interpreted as a segmentary verbal apraxia or simply a positional apraxia of the speech organs.

Speech articulation also requires the ability to switch from one syllable to another and from one word to another. This ability is controlled by the inferior premotor area of the left hemisphere that corresponds to Broca's area, traditionally considered BA44 [45]. Damage in this area results in serious language production defects characterized by an inability for programming and controlling the sequential articulatory movements (kinetic apraxia of speech) [46].This type of language disturbance was named by Luria as «efferent» or «kinetic motor aphasia», or simply Broca's aphasia. The term «kinetic motor aphasia» is suggesting the patient presents a kinetic speech apraxia. In this syndrome the motor defect is often associated with a defecit in the use of language grammar or agrammatism («telegraphic speech»). Individuals with this form of aphasia lose the ability to combine words into sentences in accordance with syntactic rules [47]. Sometimes the syntactic problems can go without an obvious articulation deficit, such cases are called syntactic aphasia. This disturbance in the use of grammar is also observed in language understanding [38, 48–49]. At the level of constructing the sentence, disorders of the expressive language include not only syntactic operations, but also semantic-lexical operations of word retrieval. We described their deficits above, speaking of language reception disorders.

Finally, language production of discourse requires having an intention, an idea, and a plan. This ability is related with the prefrontal brain areas in front of Broca's area. Luria has labeled the language disturbance observed in cases of damage to the left prefrontal lobe «dynamic aphasia». In general, it corresponds to transcortical or extrasylvian motor aphasia [50]. It is characterized by non-fluent language, good comprehension of words, sentences, simple texts, and good repetition. Prosody, articulation,

and grammar are preserved. Expressive language is limited with some tendency to echolalia and perseveration; occasionally verbal paraphasias are observed. Luria suggested individuals presenting this type of pathology have disturbance in the inner representation of a future utterance; the intention cannot be converted in an inner speech scheme, which represents the bases of utterances or narratives [1, 51]. Table 1 presents a summary of these types of language production defects.

Clinical/anatomical correlation

Except for cases of post-mortem examination, localization of lesions producing aphasia was difficult before the introduction of CT scans during the 1970s. However, Luria used a quite ingenious procedure. Considering his patients had, in most cases, bullet wounds in their brains, determining the site of the bullet entrance to the skull was not particularly difficult. Furthermore, considering the enormous amount of aphasic patients with brain wounds resulting from gunshots, it was possible to overlap the wound diagrams in a standard drawing of the skull, as it will be done several decades later with CT scans [52–54]. Using this procedure, Luria superimposed the skull diagrams of hundreds of patients and was able to determine the specific brain areas involved in different types of aphasia. This original procedure notoriously advanced the clinical/anatomical correlations in aphasia and helped to get a better understanding of the specific contribution of different cortical regions to the language system.

Brain organization of language: Final proposal (Luria, 1975/1976 [2])

The book «Basic problems of neurolinguistics» was published in Russian in 1975 and in English in 1976. One of the authors of this paper (T. Akhutina), together with known linguist I. A. Melchuk, was an editor of the Russian edition. The Russian edition is one third shorter because it is missing Chapter Two entirely. However, the text of this Chapter is close to the text of articles about neurolinguistics published in Russian[55, 56] and English [22, 23].

Luria's interpretation of aphasia slightly advanced since 1947. The major differences in aphasia interpretation between his original proposals and his final proposals [2] involved:

1. A critical analysis of some Western interpretations of aphasia mainly derived from Wernicke's ideas [56].
2. A detailed consideration of the «amnestic aphasia» and new ideas in the interpretation of semantic aphasia [55].
3. A significant emphasis on linguistic issues (appearing in his last publications).

The other difference between the books is that the first one was based on clinical cases of patients with gunshot wounds, while the second was mostly based on observations of clinical cases of aphasias caused by tumors and vascular diseases.

Aphasia re-analyzed

In his book Basic Problems of Neurolinguistics [2], Luria devotes a significant effort to analyze the Wernicke classification of aphasias, and its further developments during the 1960s and 1970s done particularly by the research group led by Norman Geschwind in Boston (the so called «Boston aphasia group»; e.g.,[57, 58]).

The entire Second Chapter and his 1973–1977 articles on neurolinguistics are devoted to analysis of conduction aphasia, transcortical motor aphasia, and amnestic (nominal) aphasia. Luria pointed out conduction aphasia does not exist in a pure form, and the repetition defects are associated with an extended group of impairments. Luria stated repetition defects could be found not only in so-called conduction aphasia, but also in acoustic-mnestic aphasia, or more exactly, two different subtypes of conduction aphasia should be separated. One of them should be associated with the afferent (kinesthetic) motor aphasia, and the other with acoustic-mnestic aphasia [1]. Noteworthy, Shallice and Warrington [59] proposed to distinguish classical conduction aphasia and its variant, caused by auditory-verbal short-term memory impairment. Kertesz [1960] introduced a similar distinction and referred to an efferent (parietal) form of conduction aphasia and also to an afferent conduction aphasia caused by lesions of temporal lobe.

Luria also presented a critical analysis of the theoretical foundations of so-called transcortical motor aphasia. He emphasized that its classical interpretation was based on a simplistic and not completely correct understanding of language/speech functioning (such as Lichtheim's scheme). He further pointed out one of the basic classical characteristics of this type of aphasia was the preservation of repetitive language. This opinion was not completely correct. These patients can usually repeat isolated words or simple sentences, but not series of words or complex sentences. Luria suggested this is an aphasia syndrome that deserves much more analysis and understanding. This type of aphasia can be regarded as a prefrontal syndrome affecting the language processes.

Finally, Luria also examined the amnestic (nominal) aphasia. He presented a detailed analysis of the naming process and its semantic aspects and distinguished different forms of amnestic aphasia. In the article written after the book, Luria summing up his analysis, wrote «the amnestic aphasia does exist, but in fact it is not one form, but a com-

Table 1. *Different types of aphasia distinguished by Luria [1] and their primary defects*

Type of aphasia	Primary defects
Disorders of language reception	
Sensory (acoustic-gnostic)	Phoneme discrimination
Acoustic-mnestic	Verbal memory
Semantic	Semantic-based selection of words and understanding of logical-grammatical constructions
Disorders of expressive language	
Afferent motor	Articuleme selection
Efferent motor	Kinetic organization of speech Grammatical structuring
Dynamic	Verbal planning and initiative

plex of forms that are based on different factors and which lead to different syndromes» [22, 55]. The first form of «amnestic aphasia» occurs in lesions of the «parietal-occipital region on the border with visual cortex» and is the result of «optico-gnostic disorders». The second form is caused by lesions of the temporal zones, «factor, leading to disruption of finding the right word is the difficulty in keeping a sound structure of the word.» The third form occurs in the syndrome of semantic aphasia «as a result of pathological conditions of the parietal-temporal-occipital cortex, in which all possible alternatives emerge with different probabilities, and the patient experiences difficulties in choosing the right word» [1, 25, 55]. In 1947, Luria differently represented the mechanism of naming disturbances in semantic aphasia, he wrote: TIn parietal, semantic aphasia, outwardly the same phenomenon of forgetting the names of objects can be the result of the collapse of the system of semantic connections, which complicates the euphoria of the necessary verbal notation.

The controversial semantic aphasia

Semantic aphasia has been a somewhat neglected and confusing type of aphasia in western aphasiology. Firstly, it is not included in the Wernicke's and derived classifications of aphasia. It was initially described only in 1926 by Head. During the 21st century, apparently only some cases of semantic aphasia, as described by Luria, have been published [42,61-63]. However, the name «semantic aphasia» has been re-introduced by some authors, but not exactly in the same way it was used by Head or Luria. So, Kertesz, et al.[64] report the case of a patient presenting loss of meaning of objects with preserved phonology and syntax. They called the described syndrome «semantic aphasia», similar to the so-called «semantic dementia», a variant of primary progressive aphasia [65]. Recently, the name semantic aphasia has been used in a similar way by several authors (e.g., [66–68].

Table 2 summarizes the different levels of language understanding, brain areas involved and types of aphasia in cases of pathology.

The linguistic approach

From the very beginning of the study of aphasia, Luria showed a profound interest in linguistics. Initially, Luria followed F. de Saussure's [69] division of language relations and opposed the «nominative» and the «predicative, syntagmatic» aspects of language, relating them to the functions of the posterior and anterior areas of the cortex [1]. In 1949, Luria wrote a paper «On Two Types of Synthetic Activity in the Cortex of the Human Brain», in which following Sechenov [70], he distinguished two kinds of operations of the brain: the synthesis of elements in simultaneous «spatial groups» and into successive «consecutive» rows [11]. The first kind of operations is performed by the posterior sections of the cortex and the second type by the anterior ones.

In 1956 the Russian-American linguist Roman Jakobson suggested two operations, «selection» (from paradigms) and «combination» (into a syntagma) underlie language processes and that they are disrupted differently in aphasia: combination is disrupted in motor aphasia (impairment of coding), while selection is disrupted in sensory aphasia (impairment of decoding) [71]. In 1964 Jakobson proposed an interpretation of the six kinds of aphasia distinguished by Luria. Besides the opposition of selection/combination and corresponding disorders of decoding and coding, he added two new ones: disintegration/limitation and successivity/simultaneity [72]. Jakobson's interpretation of aphasias was discussed and its details were criticized by Luria's pupil Ryabova -Akhutina, [73]; her opinion was very close to Luria's later point of view.

For Luria [2,22] the syntagmatic organization of language is realized by the synthesis of elements into successive «consecutive» rows and the paradigmatic organization of language is performed by the synthesis of elements in simultaneous «spatial groups». Luria emphasized disorder of the paradigmatic organization can be observed in different modalities and at different levels of language, corresponding to different aphasia subtypes: articuleme selection (afferent motor aphasia), phoneme selection (aphasia acoustic-gnostic), word selection (aphasia acoustic-mnestic), and categorical meaning selection (semantic aphasia). By the same token, the syntagmatic organization disorder can be observed at different levels: sequencing syllables into words (kinetic motor aphasiaCBroca's aphasia), words in phrases and sentences (agrammatism), and sentences in narratives (dynamic aphasiaC transcortical motor aphasia)[2].

Conclusion: What has been the Luria's fundamental contribution?

The fundamental and clinical understanding on brain organization for language has continued to advance throughout the fifty years after Luria's publications. Many of his ideas has been maintained and developed; some other proposals have been forgotten or remain controversial.

The idea that language, and in general psychological processes, represent brain functional systems has been integrated into contemporary cognitive neurosciences. Today it is consid-

Table 2. *Different levels of language production, operations of language production, corresponding types of aphasia, and brain areas involved in cases of brain pathology*

Levels of language production	Language operations	Types of aphasia	Brain areas involved
Word articulation	Articuleme selection	Afferent motor	Post-central parietal
	Kinetic programming of speech	Efferent motor (Broca)	Inferior premotor
Sentence construction	Grammatical structuring	Efferent motor / syntactic	
	Selection of word meanings and word forms	Semantic Acoustic-mnestic	Temporal-parietal-occipital Middle temporal
Message production	Verbal planning	Dynamic	Prefrontal

Table 3. *Different levels of language understanding, brain areas involved and types of aphasia in cases of pathology*

Levels of language understanding	Type of aphasia	Brain areas involved
Phoneme discrimination	Sensory aphasia	Superior temporal gyrus
Word form recognition	Acoustic-mnestic	Middle temporal gyrus
Meaning understanding – referential – categorical	 Acoustic-mnestic Amnestic (optic-mnestic) aphasia	 Middle temporal gyrus Temporal-occipital zone
Understanding of reversible sentences	Semantic aphasia	Temporal-parietal-occipital zone (TPO)

ered as a basic idea, not as a specific author's proposal. Contemporary brain research has emphasized cognitive processes are supported by brain systems or brain circuits [74–6].

His point of view that language understanding defects in cases of left posterior damage are due to phoneme discrimination disturbances, verbal memory defects, and impairments in semantic network, represents a kind of basic knowledge of aphasia today (e.g.,[77]. By the same token, his interpretation of dynamic aphasia as a disturbance in planning expressive language, and hence, close to a prefrontal (dysexecutive) syndrome affecting the language activity has been supported by different authors [78-80]. On the other hand, his interpretations of other aphasia syndromes remain polemic. For instance, should the language defects observed in cases of left parietal/post-central damage be interpreted as a segmentary ideomotor apraxia or a disconnection syndrome? It is a question that remains controversial (e.g.,[81,82]). Similarly, a clear definition of semantic aphasia awaits its solution.We really do not have a final answer. Some of his aphasia proposals, nonetheless, seemingly have returned; for instance, papers have been recently published re-taking the idea of semantic aphasia [62], that had disappeared from western aphasiology for a very long time.

An attempt to advance Luria's classification of aphasia was presented by Ardila[84] using the distinction between paradigmatic and syntagmatic language disturbances (posterior lexical/semantic disturbances; and anterior syntagmatic defects). The systematic and updated presentation of Luria's classification of aphasia, its theoretical basis, and recent data about forms of aphasia from Russian aphasiologists are given by Akhutina [38].This article is a logical continuation of the article of 1967, approved by A.R. Luria, on the use of his classification of aphasia to build a model for the generation of speech [73].

Luria was not only one of the most influential psychologists during the 20th century, but has continued as a milestone author in the 21st century cognitive neurosciences. His general theoretical interpretation that psychological processes represent «complex functional systems» is currently used in cognitive neuroscience, even though the term «complex functional system» is not necessarily used, but «brain system» [85, 87], «brain network» [88, 89], and similar terms. However, it does necessarily mean that these interpretations have been taken from Luria. It simply means Luria's theoretical interpretation on the relations between brain and cognition has turned out to be, in general, acceptable in light of 21st century knowledge.

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