

The role of the second brain functional unit II on the memory's process: A neuropsychological Luria's perspective

O papel da segunda unidade funcional do cérebro no processo de memória: Uma perspectiva neuropsicológica de Luria

El papel de la segunda unidad funcional cerebral en el proceso de la memoria: Una perspectiva neuropsicológica de Luria

Received: 07/06/2021 | Reviewed: 07/13/2021 | Accept: 07/17/2021 | Published: 07/25/2021

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Abstract

Luria, Vygotsky disciple, was a Russian neuropsychologist, that presented many data about the brain functions based on the lesions, also studied in the Moscow University and hospitals. He divided the brain functions into three units and linked to cognition aspect. Papers and books from Luria and other authors, mainly those associated to neuropsychology Luria's perspectives, were scrutinized to find data about memory linked to second functional unit with the intention to inform the modern psychologists, neurologists, psychiatrics, neuropsychologists, and neuroscientists about the epistemology used by Luria, that is scarcely known in the occident. In summary, in the second functional unit of Luria, arrive data from environment, organize them in groups of data and send for the tertiary cortex that convert this concrete data in thoughts and memories. The authors think that new studies about memory, considering Luria's data in confrontation with nowadays information, could be important to aggregate to neuropsychology theory, because some modern data were already cited by Luria/Vygotsky group in Russia in the begin of the century XX.

Keywords: Luria; Brain second functional unit; Memory; Neuropsychology.

Resumo

Luria foi um neuropsicólogo russo, discípulo de Vygotsky, que apresentou muitos dados sobre as funções cerebrais com base em lesões, estudadas na Universidade de Moscou e hospitais. Ele dividiu as funções cerebrais em três unidades, também ligadas ao aspecto cognitivo. Artigos e livros de Luria e outros autores, principalmente aqueles associados à perspectiva da neuropsicologia de Luria, foram examinados para encontrar dados sobre a memória ligada à segunda unidade funcional com a intenção de informar os modernos psicólogos, neurologistas, psiquiatras, neuropsicólogos e neurocientistas sobre a epistemologia usada por Luria, que é pouco conhecida no ocidente. Em resumo, na segunda unidade funcional de Luria chegam dados do ambiente, que são organizados em grupos de dados e enviados para o córtex terciário desta unidade, a fim de converter os dados concretos em pensamento e memórias. Os autores pensam que novos estudos sobre memória, considerando os dados de Luria em confronto com as informações atuais podem ser importantes para agregação à neuropsicologia, pois algumas teorias modernas já foram citadas pelo grupo Luria/Vygotsky na Rússia no início do século XX.

Palavras-chave: Luria; Segunda unidade funcional do cérebro; Memória; Neuropsicologia.

Resumen

Luria fue una neuropsicóloga rusa, discípula de Vygotsky, que presentó muchos datos sobre las funciones cerebrales en base a las lesiones, estudiadas en la Universidad de Moscú y en hospitales. Dividió las funciones cerebrales en tres unidades, también relacionadas con el aspecto cognitivo. Se analizaron artículos y libros de Luria y otros autores, principalmente los asociados a la neuropsicología. Las perspectivas de Luria, para encontrar datos sobre la memoria vinculados a la segunda unidad funcional con la intención de informar a los psicólogos, neurólogos, psiquiatras, neuropsicólogos y neurocientíficos modernos sobre la epistemología utilizada por Luria, eso es poco conocido en occidente. En resumen, en la segunda unidad funcional de Luria llegan datos del entorno, los organiza en grupos de datos y los envía a la corteza terciaria que convierte los datos concretos en pensamientos y recuerdos. Los autores piensan que los nuevos estudios sobre la memoria que consideran los datos de Luria en confrontación con la información actual, podrían ser importantes para agregar a la teoría de la neuropsicología porque algunos datos modernos fueron citados por el grupo Luria / Vygotsky en el ruso a principios del siglo XX.

Palabras clave: Luria; Segunda unidad funcional del cerebro; Memoria; Neuropsicología.

1. Introduction

For a layman, it may sound impossible that someone could mistake the right side of their body with that of another person (Luria, 2008). However, it can take place due to a specific brain disease, and it does change human behaviour, ranging from simple motor or afferent functions to more complex conditions, such as psychological alterations that are very hard to understand (Luria, 1973).

Most of the cerebral functions are quite difficult to understand, such as speeding, thinking, memorization and even a couple of movements from the upper motor neurons. In particular, memory is related to simple movements controlled by the medulla, such as sensitive or afferent movements controlled by the cerebellum and even recalling past memories kept in the cortex according to Vygotsky/Luria general propose; however, nowadays, the memory concept is more complex and consider beyond the process to stoke data a dynamic construction and in evolution with internal and external aspects, as the memory stoked outside the brain (Zlotnik & Vansintjan, 2019). Indeed, not only is memory loss an issue for humans but also an extensive memory can generate behaviour and cognitive alterations (Vygotsky, 1956, 1960, 2004; Luria, 1971, 1973, 2015a), for instance, the working memory, hodiern, is closely linked to attention (Angelopoulou & Drigas, 2021).

There are plenty of studies that have shown that algorithms are effective at representing the brain circuits. They have the intention to generate artificial intelligence in computer networks (Yadav; Sharma & Yadav, 2014). These papers, including those from the exact sciences, consider a few fields, such as biochemistry, physiology, psychology, ethology, and software engineering, to understand how our brain works.

Nonetheless, all the basic and complex memory types are not located in a specific cerebral area. They are possibly located in multiple areas, such as the occipital, temporal, parietal, and frontal cortices. These areas can use past data to build (Luria, 1973, 2008, 2015a, 2015b) the base of thinking and reasoning linked to future perspectives (Aversi-Ferreira, 2014).

Indeed, there is a strong connection between memory and the act of persistence in learning (Squire, 1987). It is a constant process linked to studies in general according to a few education theories (Alves & Aversi-Ferreira, 2019; Castro, Nishijo & Aversi-Ferreira, 2018). Therefore, it is thoroughly part of human existence once the beginning of the society in human history is toughly dependent on the memories that cross generations dependent, also, of the speech evolution (Luria, 10973; Aversi-Ferreira et al., 2021).

Despite a lot of studies about the memories hodiern, a Russian neuropsychologist named Alexander Romanovich Luria, a disciple of Vygotsky (Luria, 2015b; Aversi-Ferreira et al., 2019), studied the historic social cultural psychology/philosophy aspects of memory and used many patients from local hospitals and clinics (see Kostyanaya & Rossow (2013) for more detailed Luria's history).

In a plenty of books, Luria wrote about memory with multiple foci, for instance, a Russian mnemonist (Luria, 2015a). In another book, he told us about a patient with a temporo-parieto-occipital lesion who had memory loss, particularly affecting

long past memories (Luria, 2008). In relation to physiologic and psychologic lesions, the concepts and explanations of memory are cited in many topics of the book titled “The Working Brain” (Luria, 1973), and another book called “Neurophysiology of Memory” (Luria, 1973).

Due to the Cold War, a lot of studies from Luria had not been read by occidental scientists, especially psychologists and neuroscientists in general (see the preface of the book “The Man with a Shattered World: The History of a Brain Wound” written by Oliver Sacks) (Luria, 2008; Aversi-Ferreira et al., 2019). This is the reason why a lot of studies performed in Occident have never cited Luria’s work effort. Indeed, a few authors have studied Luria’s work to present his ideas in Occident (Aversi-Ferreira et al., 2019; Aversi-Ferreira et al., 2010).

In this time, Vygotsky and his disciples created a social-historical-cultural philosophy (Aversi-Ferreira et al., 2019) whose mind constructions occur according to the social contact between humans and language (Aversi-Ferreira et al., 2021), not only as a genetic product but also as an environmental one (Luria, 2015b); a deep and intriguing view well accepted by many researchers to explain the human mind as an entity that crosses the morphologic and physiologic boundaries of the brain and integrates multiple upper abilities of humans (Barroco & Souza, 2012).

Luria also considers the brain phenomenon as an associated phenomenon represented not only by a specific function but also by a harmonious conjunct, like an orchestra in which each of the brain’s components act as a musical instrument (Aversi-Ferreira et al., 2010). Therefore, aspects such as memory, language and thoughts are not only located in a specific brain area but also in many brain areas, since they all work together (Luria, 1973).

Thus, the psychology social-historic-cultural database from Luria and Vygotsky are quite important to understand how the brain works. Hypothetically, the neuropsychological approach could increase brain function comprehension and that is exactly how Luria’s theories could help them.

From this view, the aim of this study is to show Luria’s ideas about the neuropsychology of memory on the function of the second functional brain unit and also to express them to psychologists, psychiatrists, neurologists and neuroscientists in general.

2. Methodology

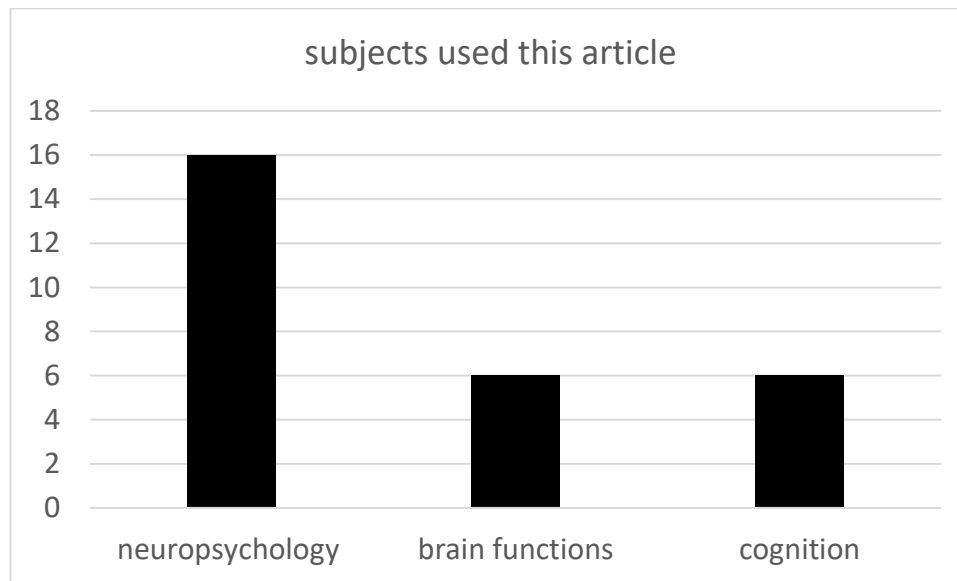
The book “The Working Brain” (Luria, 1973) was the main source to write this article. Furthermore, a few papers from Vygotsky and other books and articles from Luria, including articles published after 1970 (Table 1; Figure 1), were also sources of inspiration. Valuable information about neuropsychology and memory, based on the second functional cerebral unit (in line with Luria’s proposal of splitting the cerebral zone into three functional units), were explored in the source texts. Works were chosen to find data about the memory, specifically about the second functional unit from Luria's proposal. Also, topics about neuropsychology [16], brain function [6] and cognition [6] were included (Table 1; Figure 1).

Table 1. Texts and subjects studied in this article considering the subjects.

	Texts	Subjects
1.	Alves, P. A. & Aversi-Ferreira, T. A. (2019). Comments on the Problems Solving Methodology in Education of Civil Engineering in Brazil. <i>RBECT</i> . 2(1):134-153.	Cognition
2.	Angelopoulou, E., & Drigas, A. (2021). Working memory, attention and their relationship: A theoretical overview. <i>Research, Society and Development</i> , 10(5), e46410515288. https://doi.org/10.33448/rsd-v10i5.15288	Cognition
3.	Aversi-Ferreira, T. A., Borges, K. C. M., Gonçalves-Mendes, M. T., Caixeta, L. F.(2021) Gross anatomy of the longitudinal fascicle of <i>Sapajus</i> sp. <i>PLoS ONE</i> 16(6): e0252178. https://doi.org/10.1371/journal.pone.0252178	Brain functions
4.	Aversi-Ferreira, T. A, Tamaishi-Watanabe, B. H., Magri, M. P. F. & Aversi-Ferreira, R. A. (2019). Neuropsychology of the temporal lobe: Luria's and contemporary conceptions. <i>Dement. Neuropsychol.</i> 13(3):251-258.	Neuropsychology
5.	Aversi-Ferreira, T. A. Neuroarquitetura e Neuroconectividade nas Ciências Cognitivas e do Comportamento. In: Leonardo Caixeta (Org.): <i>Tratado de Neuropsiquiatria: Neurologia Cognitiva e do Comportamento e Neuropsicologia</i> . São Paulo: Atheneu. 2014.	Neuropsychology
6.	Aversi-Ferreira, T.A., Araújo, M. F. P., Lopes, D. B. & Nishijo H. (2010). History, cytoarchitecture and neurophysiology of human and non-human primates' parietal lobe: a review. <i>Dement. Neuropsychol.</i> 4(3):173-180.	Neuropsychology
7.	Bersntein, N. A. (1947). <i>The construction of movement</i> . Moscow: Medigiz.	Brain functions
8.	Bersntein, N. A. (1967). <i>The coordination and regulation of movements</i> . Oxford: Pregamon Press.	Brain functions
9.	Barroco, S. M. S. & Souza, M. P. R. (2012). Historical-cultural psychology contributions to the psychologist's professional training and practice in the context of inclusive education. <i>Psicol. USP</i> . 23(1):111-132.	Neuropsychology
10.	Campbell, A. W. (1905). <i>Histological studies on the localization of cerebral function</i> . Cambridge: Cambridge University Press.	Brain functions
11.	Castro, S. K. A., Hisao, N. & Aversi-Ferreira, T. A. (2018). Neuroanatomy teaching: an example of active teaching applied to medical formation. <i>American Journal of Educational Research and Reviews</i> . 3(37).	Cognition
12.	Grønli, J. & Ursin, R. (2009). [Basic sleep mechanisms]. <i>Tidsskrift for den Norske laegeforening: tidsskrift for praktisk medicin, ny raekke</i> , 129(17), 1758-1761. http://doi: 10.4045/tidsskr.08.0465	Neuropsychology
13.	Kostyanaya, M. I. & Rossouw, P. (2013). Alexander Luria – life, research and contribution to neuroscience. <i>International Journal of Neuropsychotherapy</i> , 1(2), 47-55. http://doi: 10.12744/ijnpt.2013.0047-0055	Neuropsychology
14.	Luria, A. R. <i>The Working Brain: An introduction to Neuropsychology</i> . New York: Basic Books. 1973.	Neuropsychology
15.	Luria, A. R. <i>Desenvolvimento Cognitivo: seus fundamentos culturais e sociais</i> . São Paulo: Martins Fontes. 1999.	Neuropsychology
16.	Luria, A. R. <i>O homem com o mundo estilhaçado</i> . Petrópolis: Vozes. 2008.	Neuropsychology
17.	Luria, A. R. <i>A mente e a memória: um pequeno livro sobre uma vasta memória</i> . São Paulo: Icone. 2015a.	Neuropsychology
18.	Luria, A. R. <i>A construção da mente</i> . São Paulo: Icone. 2015b.	Neuropsychology
19.	Standring S (2008). <i>The anatomical basis of clinical practice</i> . London: Churchill Livingstone. pp 839–898.	Brain functions
20.	Stretton, J. & Thompson, P. J. (2012). Frontal lobe function in temporal lobe epilepsy. <i>Epilepsy Research</i> , 98(1), 1–13. http://doi: 10.1016/j.eplepsyres.2011.10.009	Brain functions
21.	Squire, L. R. <i>Memory and brain</i> . New York: Oxford University Press. 1987.	Cognition
22.	Yadav, P., Sharma, V. & Yadav, P. (2014). Cache memory – various algorithm. <i>IJCSMC</i> . 3(9):838-840.	Cognition
23.	Vygotsky, L. S. (1960). <i>Development of higher psychological function</i> . Moscow: APN RSFSR.	Neuropsychology
24.	Vygotsky, L. S. (1956). <i>Selected psychological studies</i> . Moscow: Izd. APN RSFSR.	Neuropsychology
25.	Vygotsky, L. S. (2004). <i>Teoria e método em psicologia</i> . Sao Paulo: Martins Fontes.	Neuropsychology
26.	Zlotnik, G. & Vansintjan, A. (2019). Memory: An Extended Definition. <i>Front. Psychol.</i> 10:2523. doi: 10.3389/fpsyg.2019.02523	Cognitionglobo.com

Source: Authors.

Figure 1. Quantitative data of the subjects used to perform this article.



Source: Authors.

3. Results and Discussion

The book “The Working Brain” (Luria, 1973) the memory research is based on a neuropsychological approach considering aspects from the II functional unit and a specific chapter including other aspects. In another book from Luria, “The Mind of a Mnemonist: A Little Book about a Vast Memory” (Luria, 2015a), he analyses a man with an exceptional memory. Another great example is the book titled “The Man with a Shattered World: The History of a Brain Wound” (Luria, 2008). It is about issues linked to the third functional unit of the brain, which is inside the temporo-parieto-occipital area. In addition, the memory process, in general, is explained in a few books, such as “The Making of Mind” (Luria, 2015b) and “Cognitive Development: Its Cultural and Social Foundations” (Luria, 1999) (Table 1).

The sum of data to discuss the neuropsychology of memory into Luria’s epistemology is made by books and papers published by him and other authors before 1970.

Luria divided all brain functions into three functional units (Luria, 1973; Téllez & Sánchez, 2016). So, the foundation of his work is based on that. Briefly, unit I is responsible for regulating and waking mental states (Grønli, & Ursin, 2009; Téllez & Sánchez, 2016); unit II is responsible for receiving, analysing and storing information (Luria, 1973; Téllez & Sánchez, 2016); and unit III is in charge of programming, regulating and certificating cerebral activities (Luria, 1973; Stretton & Thompson, 2012; Téllez & Sánchez, 2016).

All the units are related to the consolidation of memory, especially unit I, which contains the reticular formation, whose fibres ascend, *inter alia*, to the rhinencephalon, which is linked to conscience and memory storage. Therefore, a random issue in any of these regions controlled by unit I can interfere with the mnemonics process in a non-specific way, since this unit keeps the entire brain in tonus. In addition, injuries in the medial zones of the frontal lobes can cause inhibition of the stimulus that is received in those areas controlled by unit I. Also, a stronger stimulus interferes with the others in progress. This mechanism can be explained by an important clinical feature in Korsakoff’s syndrome. For instance, if a patient is looking at a ball and a different object is shown, he will certainly forget about the ball and only remember the second object (Luria, 1973).

However, the main aim of this work is to study the functional unit II of the brain (secondary area), which is responsible for specific memories. This unit is in the convex region of the lateral part of the encephalon, specifically in the junction among the parietal-temporal-occipital area (Téllez & Sánchez, 2016,) which is accounts for visual, hearing and general sensorial

functions. These areas receive information from the periphery of the body and make the disintegration of this information into functional dynamic groups, which are established in a standard way into Brodmann areas 17 (occipital lobe); 1 and 3 (parietal lobe); and 41 (temporal lobe) (Stranding, 2014). Thus, this organization has high specificity. Then, all decomposed information arrives in the fourth layer of the afferent cortices, also known as the primary area, where the neurons are deeply specific for each sensation.

After this, the sensitive information is received by layers II and III. These layers receive the data in the associative neurons, which are less specific, and perform a synthetic function. They also form the secondary area, located specifically in Brodmann areas 18 and 19 (occipital lobe); 21 and 22 (temporal lobe); and 1, 3, 5 and part of 40 (parietal lobe).

Indeed, in similar and close areas, as well as across over each other, the primary and secondary areas of afferent reception are found. For instance, Brodmann areas 3 (parietal cortex) and 40 (temporal cortex) only have differences related to their architectonic organization. In other words, the size (thickness) of layer IV (primary area) and layers II and III (secondary area) are distinct. These areas are organized in a somatotopic way in the brain (Stranding, 2008).

Also, in reference to the above information, it has been observed that the stimulation of the primary cortex evokes a specific sensation in the body. However, stimulation in the secondary areas evokes a complex mode of cutaneous sensation in Brodmann areas 1, 3 and 5 particularly. In other words, the stimulation of the primary and secondary areas results in different types of sensations. In the meantime, these areas are superimposed but follow a main hierarchical organization, as it is noticeable in the parietal cortex (Campbell, 1905).

Thus, the primary and secondary areas are importantly involved with memory processing, also known as a superior cerebral function. They store data for memory operations, not in a modal-specific organization, but in a multimodal way. After passing from these two areas, the information is linked to the tertiary area in functional unit II, which contains many small associative neurons that work together, resulting in a deeply specific area. It is located in the temporo-parieto-occipital region, and its volume is larger when compared to primates. As an accurate location, this area corresponds to Brodmann areas 5, 7, 40, 21, 37 and 39.

In this specific region, the packages that have concrete perceptions are converted into abstract perceptions, which have already been codified by the brain. To put it another way, the information, such as a visual perception, is transformed into synthetic data, and then, it has made a transition, from this concrete perception to symbols, words, grammatical organization, and logic process, that is an abstract perception.

For instance, to perform a complex motor movement, it is necessary specific and precise information of the localization of the limbs. If this localization is not accurate enough, in other words, if there is a failure in the sensitive-memory system, the movement cannot be effectuated (Bernstein, 1947, 1967).

So, the regions in the II functional unit that accomplish the synthetic functions are in the tertiary areas, which contain many granular cells and analysers, building the associative layers II and III, that act harmoniously, even if it is located in an area of overlap, such as the occipital cortex and temporal and inferior parietal areas (Luria, 1973, 2008).

In addition, those cited regions are in Brodmann areas 3, 7, 21, 37, 39 and 40. It is observed as a superposition to the secondary areas. Shortly, these areas integrate information to build the visual system and also perform the conversion of visual perceptions into abstract wonders, such as the conversion of words into a grammatical and logical sentence. Strictly speaking, the tertiary zone converts the concrete perception into abstract thinking by the internal processing and memory organization.

A recent study claims that the major goal of the memory studies is the knowledge about its cognitive process kept by the nets and brain's systems (Eichenbaum, 2017) citing the role of the prefrontal cortex in control it and the importance of the hippocampus. Interesting, the control of the memory by the prefrontal cortex was indicated by Luria, however, it was cited as

new findings in the last decade. On the other hand, Luria did not consider the hippocampus as having an important role for memory process.

The above comment indicate that Luria's studied indeed is underestimated in the Occident but, new data must be summed to the ancient discoveries to deep the knowledge of brain, including the memory' functions and its structural basis, mainly considering the new images techniques for brain studies (Aversi-Ferreira et al., 2019).

Despite the new concepts of memory, the Luria/Vygotsky studies indicate a good way for the understanding of the memory's process, as it works and it structural basis, because the idea of the historic-socio-cultural psychology anticipated the modern and deeper concept of memory that considers it external storage. This could be an important aspect to studied by psychologist/neuroscientist about the historic-socio-cultural philosophy in relation to the new conception of the memory considering it external aspects, because the perspectives of the social interactions for cognition cited by Luria and Vygotsky include the external stimulus for brain evolution, but the computer and internet technologies was not discussed by them, obviously.

4. Conclusion

The process of the memory according to the functions of the second brain unit shows the receiving of the data from the environment in the primary cortex, and the discrimination of these data in the secondary zones and the organization of synthetic processes in the tertiary cortex, generating a high cognitive activity in the region temporo-parieto-occipital and converting the concrete data in abstract thinking.

However, detailed data about the memory studies was performed by Luria until the 1970s, considering the non-specific and specific memory types linking this information, respectively, to functional units I and II, and a detailed study about the general process involving the many regions linked to memory processes could be performed in other studies now comparing the Luria's perspectives with others.

Acknowledgments

The authors are grateful for the helpful comments made by the anonymous reviewers who improved the presentation and scientific quality of this article

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