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## CONTENTS



## СОДЕРЖАНИЕ

# From the Editorial Board

The large international editorial board is happy to present the first issue of the new interdisciplinary psychological journal — LURIAN JOURNAL. This is an important event in the international psychological life.

The new magazine must move away from repeating the great contributions of Luria. As it was said, "not moving forward is going backwards" (in Latin: "non progredi est regredi"). It does not mean, the journal should cut off the roots, forget about tradition. However, this does not exclude the possibility of advanced research and publication of interesting results. This new journal will be not about Luria's works but about his systemic approach: this is a journal focused on a specific approach in psychology. The journal will expose different aspects of the same theory and how the neo Lurian professionals revisit Luria's thoughts and use it in their practices.

The great value of Luria's ideas, as part of what is called a "cultural-historical theory" is that it is entirely relevant to the movements we see called by such names as "cultural neurosciences", "cultural-cognitive science", as well as "cultural neuropsychology". These modes of thought all accept the idea of development emerging from the intertwining of phylogenetic, cultural — historical, ontogenetic, and microgenetic processes. Thus, Luria's systemic approach serves as a meta theory for a broad bio-social, cultural-historical understanding of humans.

We should never forget the brain and its neural connections, the individual, social and cultural mind, and individual, social and cultural self, as it was stated by Luria. Luria always had the brain as a reference.

We see the magazine as a way to promote Luria's approach, without falling into a conceptual myopia. The journal should be a creative and constructive project, that looks to the future, that advances taking the attitude of Alexander Romanowich Luria towards science. Reading the list of Luria's publications makes us aware of a wide range of his interests: from the cerebral location of mental functions, through methods of rehabilitation and education, cognitive processing, issues of language, intellectual development or the impact of culture on human development, to intercultural research.

This new journal will be a vehicle to develop Luria's ideas in different areas, including not only theoretical but also clinical questions. The journal would like to see articles that focus on the methodological principles that develop the ideas of A. R. Luria in modern research.

People all over the world will share new ideas about Luria's theory. It is an important opportunity to share experiences and to learn new ways of thinking and working with an approach so interesting and important in the psychology.

Probably one of the objectives of the journal is to capture the consistency and chronology of neuropsychology development. Moreover, Luria's ideas are of crucial importance for modern neuropsycholinguistics. What A. Luria discovered by, among other things, scientific intuition, is now possible to verify it using modern technologies.

We consider that the journal should represent the new trends in neuroscience and neuropsychology however aligned with the Luria's methodology and ideas. The journal will take into account the cultural and social aspects of neuropsychology.

The magazine is also an instrument to spread the work of great Russian scientists who worked with, or influenced Luria (Anokhin, Sokolov, Polyakov, Bernstein, Vygotski, Leontiev, Halperin, Zeigarnik et al.). Obviously, without forgetting his students.

An important and attractive part of the new journal could be the problem of development of higher mental functions, where the ideas of Vygotsky and Luria are closely intertwined and which is a primordial trend of the cultural-historical psychology. As Luria and Vygotsky claimed, a work with a defect should not be a defectology, but a surmounting, an interdisciplinary help to children and adults with special needs. We also welcome articles about relation between neuropsychology and education.

It is important to analyze how the patient represent and what he is doing with own troubled mind (psychology of pathology instead of pathology of psyche).

These different topics may contribute to the journal becoming cross-disciplinary and attractive for various groups of readers.

The authors should be encouraged to submit the following kinds of articles:

1. *Original articles* — reports of previously unpublished results from scientific experiments or observations conducted by the authors in order to confirm or refute a clearly identified hypothesis.
2. *Research methodology* — authorial discussions of methodologies, important issues, controversies, and schools of thought in different areas of psychology.
3. *Case studies* — involving an up-close, in-depth, and detailed examination of a particular case. Case study research can mean single and multiple case studies, can include quantitative evidence, relies on multiple sources of evidence, and benefits from the prior development of theoretical propositions. Case studies may involve both qualitative and quantitative research method.
4. *Review papers* & *Open Forum* — reports on the current state of knowledge in a given area or field of study, especially current controversies, theoretical and practical approaches to the issues, unresolved problems, etc., with carefully selected references to the literature.

In addition, we mind that all --papers should include some reference of A. R. Luria's work, cultural historical approach and activity theory authors and relation between modern state of development of psychology and neuropsychology.

To conclude, Luria's approach and ideas will distinguish this journal among others; will bring new senses and meanings. It should never be the magazine of "a group of Lurianist friends" (or "uncultured" pseudo-lurianists, who don't really know Luria's work). Our editorial board is a group of very critical and creative scientists who take Luria as a methodological reference. The journal will develop original Lurian ideas, and show their significance in the light of new discoveries, recent references, topics of interest, appropriate methodology. Today when we see a lot of empirical data thanks to new research techniques, there is a real value in systemic-dynamic approach for seeing a wider picture. New headings can be created according to readers' requests. This journal will be always open for new ideas.

# GREETINGS

# ПРИВЕТСТВИЯ

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# *Greetings From the Ural Federal University*

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# *Приветствие от Уральского федерального университета*

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## Dear Colleagues, Welcome to the Lurian Journal!

The beginning of 2020 is marked by a significant event in scientific life of Ural Federal University in the sphere of psychology. For the first time in Russian psychology a journal aimed at preserving the legacy of Alexander Luria is started.

It is no coincidence that the Lurian Journal is initiated in the Ural region, where Alexander Romanovich Luria was a head of a large neurosurgical evacuation hospital in the settlement of Kisegach, Chelyabinsk region in 1941–1944. During this period, A. R. Luria and his staff had initiated the research and rehabilitation practice for patients with head injuries. That period made a significant contribution to the development of neuropsychological science.

Today, the Journal is focused on the development of Russian and world neu-

## Уважаемые коллеги, приветствуем вас на страницах "Lurian Journal"!

Начало 2020 г. ознаменовано значимым событием в научной психологической жизни Уральского федерального университета. Впервые начинает работу психологический журнал, ориентированный на сохранение наследия Александра Романовича Лурия.

Неслучайным является открытие "Lurian Journal" именно на Урале, где с 1941 по 1944 г. Александр Романович руководил крупным нейрохирургическим эвакогоспиталем в поселке Кисегач Челябинской области. В эти годы А. Р. Лурия и его сотрудниками был проведен ряд исследований по проблемам реабилитации раненых с травмами головы. Именно данный период внес весомый вклад в развитие, прежде всего, нейропсихологической науки.

ropsychological science by consolidating the results of the latest achievements in theoretical, experimental and applied neuropsychology. It also aims at scientific popularization of research into individual differences of people in the process of their mental, personal and professional development, their self-actualization in response to digitalization.

Joint work with outstanding scientists and experts will undoubtedly contribute to a high quality of published papers. The Journal partners include the psychologists from the Faculty of Psychology at Lomonosov Moscow State University, the Russian Academy of Education, the Russian Psychological Society and a number of scientific and psychological world centers: the American Psychological Association, the Polish Society of Neuropsychology, the Integrative Center for Neuropsychology and Psychology (Brazil), Lev Vygotsky Institute (Portugal), etc.

Everyone who is interested in preserving the heritage of A. R. Luria and developing it in contemporary context is invited for publication. We hope that the Journal will make a significant contribution to the development of Russian and world psychology!

Сегодня журнал ориентирован на взаимодействие российской и мировой нейропсихологической науки путем консолидации результатов актуальных теоретических, экспериментальных и прикладных нейропсихологических исследований, в сферу его интересов также входит научная популяризация исследований индивидуальных различий субъектов в процессе психического и личностного развития, профессионального становления, самореализации в условиях цифровизации.

Несомненно, совместная работа над журналом с преподавателями факультета психологии Московского государственного университета имени М. В. Ломоносова и поддержка Российской академии образования, Российского психологического общества и ряда научных психологических центров мира: Американской психологической ассоциации, Польского общества нейропсихологии, Центра интеграции нейропсихологии и психологии (Бразилия), Института психологии им. Л. С. Выготского (Португалия) и др., позволят поддерживать высокое качество публикуемых в журнале статей.

Приглашаем к публикации всех, кто заинтересован в сохранении наследия А. Р. Лурия и его развитии в современных условиях. Надеемся, что данный журнал внесет весомый вклад в российскую и мировую психологию!

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# *Greetings From the Lomonosov Moscow State University*

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# *Приветствие от Московского государственного университета*

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**Dear colleagues,**
**I am pleased to welcome you**
**in the issue of the Lurian Journal!**

Release of a new journal is a remarkable event for the scientific community. But the first issue of the Lurian journal is particularly noteworthy, since it springs into existence in the dramatic COVID-19 pandemic context!

We can't but agree that a certain professional continuity can be observed in it. Likewise, during WW2, psychologists did not stand aside from the common cause. Many of them made an invaluable contribution to the Victory, using psychological research findings to solve urgent applied issues set by wartime. Among them was Alexander Romanovich Luria, who gained

**Уважаемые коллеги,**
**приветствую вас**
**на страницах "Lurian Journal"!**

Выпуск нового журнала — яркое событие в жизни научного сообщества. Но именно первый номер "Lurian Journal" хочется отметить особо, так как он появился в непростой для всего мира ситуации пандемии COVID-19!

Согласитесь, что в этом усматривается некоторая профессиональная преемственность. Так, в годы Великой Отечественной войны не остались в стороне от общего дела и психологи. Многие из них внесли неоценимый вклад в достижение победы, применяя психологические разработки и результаты психологических исследований

a worldwide recognition as a founder of the Soviet neuropsychological school.

He wrote: "The whole country was seized by a spirit of shared responsibility and common goal. Each of us knew that we had to unite with our compatriots in order to confront the mortal danger. Each of us had to find one's own place in this struggle — either to defend our country on the battlefield, or work in the defense industry that was evacuated to remote areas of the country, or restore health and working ability of the wounded" (Luria A. R. (1982). The Stages Gone Through: A Scientific Autobiography (p. 129). Moscow: Publ. MSU). In the first months of the war in the Southern Urals, in the settlement of Kisegach near Chelyabinsk, Alexander Romanovich was a head of the home front neurosurgical rehabilitation hospital.

Today, in the current pandemic situation, Lurian neuropsychologists work together with doctors in neurological clinics which are redesigned to provide medical care to patients with COVID-19. Armed with the achievements of the Russian School of Psychology laid by L. S. Vygotsky — A. N. Leontiev — A. R. Luria, they study the negative psychological phenomena caused by the pandemic; develop clinical recommendations for patients, their relatives, medical workers, psychologists themselves, that help to cope with the negative effects of coronavirus infection; provide counselling for all target groups that are most vulnerable to the pandemic.

In this situation, my colleagues and I (A. Sh. Tkhostov, V. V. Drummer, N. A. Varako, A. A. Skvortsov, M. S. Kovyazin) had the opportunity to unite efв решении важнейших прикладных задач, поставленных военным временем. Среди них был и известный сегодня во всем мире основатель советской нейропсихологической школы Александр Романович Лурия.

Он писал: "Чувство общей ответственности и общей цели охватило всю страну. Каждый из нас знал, что мы обязаны объединиться с нашими соотечественниками, чтобы противостоять смертельной опасности. Каждый из нас должен был найти свое место в этой борьбе — или непосредственно защищая свою страну, или работая в оборонной промышленности, которая была эвакуирована в отдаленные районы страны, или восстанавливая здоровье и трудоспособность раненых" (*Лурия А. Р.* Этапы пройденного пути : науч. биогр. М. : Изд-во МГУ, 1982. С. 129). В первые месяцы войны на Южном Урале, в маленьком поселке Кисегач близ Челябинска под руководством Александра Романовича был организован тыловой восстановительный госпиталь нейрохирургического профиля.

Так и сегодня, в сложившейся пандемической ситуации, нейропсихологи работают вместе с другими врачами в неврологических клиниках, перепрофилированных под оказание медицинской помощи пациентам с COVID-19. Вооруженные знаниями отечественной психологической школы Л. С. Выготского — А. Н. Леонтьева — А. Р. Лурия, они занимаются изучением негативных психологических феноменов, вызванных пандемией; разрабатывают клинические рекомендации для пациентов, их родственников, медицинских работников и самих психологов, помогающих пре-

forts and render assistance to the team of doctors and psychologists of the Federal State Budgetary Institution "Federal Center for Brain and Neurotechnology FMBA", under the direction of V. V. Belousova and R. T. Tairova. As in those far-off wartime years, doctors again turned to psychologists for help to overcome various difficulties that arose or escalated during the epidemic. It included assistance to medical workers who face the most severe stress resulting from the changing working environment; to their relatives (including children and the older generation), who are in constant suspenseful wait to meet their loved ones working in dangerous conditions and fear for their life and health; to patients who face uncertainty caused by the serious disease; to their relatives who are unable to communicate with their family members and medical staff; to many other categories of people that need psychological assistance.

I am very grateful to the entire staff of the Center for the unique experience that the psychologists of Moscow State University named after M. V. Lomonosov acquired while exercising their professional duty in the adverse and unpredictable situation of the pandemic.

Rapid changes in the living conditions of modern society that include a wide spread of digital technologies, the use of artificial intelligence, increased informatization, virtualization alongside with uncertainty, turbulence and social polyphonism create new challenges for psychologists. A scope of these challenges is vast: from the development and implementation of new ethical standards, risk assessment and forecasting of a person's socialization up to creating unique opportunities for solving

одолевать негативные последствия коронавирусной инфекции; осуществляют консультативную работу для всех целевых групп, которые оказались наиболее уязвимыми для последствий пандемии.

В этой ситуации мне и моим коллегам (А. Ш. Тхостову, В. В. Барабанщиковой, Н. А. Варако, А. А. Скворцову, М. С. Ковязиной) также довелось помогать коллективу врачей и психологов Федерального центра мозга и нейротехнологий под руководством В. В. Белоусова и Р. Т. Таировой. Как и в далекие военные годы, врачи вновь обратились за помощью к психологам для преодоления различных трудностей, которые возникли или обострились на фоне эпидемии: это и помощь медицинским работникам, испытывающим тяжелейший стресс в результате изменившихся условий труда, и их родным (в том числе детям и старшему поколению), находящимся в постоянном напряженном ожидании встречи со своими работающими в опасных условиях близкими и страхе за их жизнь и здоровье, и пациентам, оказавшимся в ситуации неопределенности тяжелого заболевания, и родственникам пациентов, не имеющим возможности для обычного человеческого общения с близкими и с медицинским персоналом, и многим другим категориям людей, нуждающимся в психологической помощи.

Я очень признателен всему коллективу Центра за тот уникальный опыт, который приобрели психологи МГУ, осуществляя свой профессиональный долг в непростой и непредсказуемой ситуации пандемии.

Стремительно меняющиеся условия жизни современного общества — активное распространение цифровых техно-

fundamental scientific issues which refer to the functioning of consciousness, developing methodological foundations for new scientific areas (i. e., safety psychology, cyberpsychology). The most topical issues comprise high-tech cognitive research, the use of new methods of data processing, including large database analysis. The pandemic situation has reinforced the relevance of Psychological Science for the development of innovative practical and managerial solutions in the sphere of neuropsychology and psychological assistance in general. In this respect it is important to note that the Lurian Journal aims to determine the development prospects and new directions of modern neuroscience and psychology.

It is remarkable that the journal seeks to respond to the urgent needs of the interdisciplinary and multidisciplinary research; plans to publish original theoretical and experimental papers in the fields of cognitive psychology, general, social and educational psychology, psychophysiology and clinical psychology, bio- and neuromedicine, neuroscience; focuses on uniting scientific efforts of the leading researchers and world-class experts in the sphere of psychological sciences and neurotechnologies.

I feel confident that the available scientific potential of the followers of the outstanding Russian neuropsychologist, A. R. Luria, and our unique shared experience of psychological follow-up in COVID-19 pandemic will contribute to enhancing the Journal status as well as opening up new worldwide horizons for the Russian School of Neuropsychology.

логий, использование искусственного интеллекта, возрастающая информатизация, виртуализация, неопределенность, турбулентность и социальный полифонизм, ставят перед специалистами в области психологии серьезные вызовы: от разработки и внедрения новых этических норм, оценки и прогноза рисков цифровой социализации человека до уникальных возможностей решения фундаментальных научных вопросов функционирования сознания, разработки методологических основ новых научных направлений (например, психология информационной безопасности, киберпсихология). Актуальными становятся высокотехнологичные когнитивные исследования, использование новых методов обработки данных, в том числе анализа больших баз данных. И ситуация пандемии только усилила актуальность психологической науки, ее востребованность для разработки инновационных практических и управленческих решений в области нейропсихологии и психологической помощи в целом. И здесь важно отметить, что “Lurian Journal” ставит своей целью именно определение перспектив развития и новых направлений современной нейронауки и психологии.

Примечательно, что журнал, отвечая актуальным запросам междисциплинарных и мультидисциплинарных исследований, планирует публикации оригинальных теоретических и экспериментальных работ в областях когнитивной психологии, общей, социальной и педагогической психологии, психофизиологии и клинической психологии, био- и нейромедицины, нейронауки, что, несомненно, будет способствовать консолидации научного поиска ведущих

исследователей и специалистов мирового уровня в области психологических наук и нейротехнологий.

Уверен, что имеющийся научный потенциал последователей великого отечественного нейропсихолога А. Р. Лурия и наш совместный уникальный опыт психологического сопровождения в условиях пандемии COVID-19 позволят не только повысить статус журнала, но и вывести отечественную нейропсихологическую школу на новый мировой уровень.

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## *Greetings From the American Psychological Association*

# Neuropsychology: Reaching a Promise Land for Psychology

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USA, Wilmington

## *Приветствие от Американской психологической ассоциации*

# Нейропсихология: земля обетованная для психологии

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For far too long psychology in the east and west have not interfaced sufficiently. With the globalization of thought, thinking, brain, mind and consciousness the two historical powers in the history of psychology — Russia and the United States have no choice but to join forces to bring the best that these two approaches to thinking about psychology and the world's problems. This is a time for unification and amalgamation of ideas, systems and forces as a means to become a stronger and more applicable psychology. Towards this goal, neuropsychology is the best suited specialty within psychology to bridge this existing gap. The tensions between ideologies do little to address the grave and impending problems facing all of us. From climate change to overpopulation to continuing misunderstandings between people and peoples are some of the pressing issues in which psychology, and, specifically, neuropsychology may bring to furthering understanding and providing viable solutions.

There is no better solution than to bring psychology back to the roots from both Russia, via Ivan Pavlov, and the United States, via William James. Pavlov seminal book, *Conditioned Reflexes* provides us with a glimpse of what psychology is and should be. The subtitle provides the most comprehensive glimpse of his thinking- *An investigation of the physiological activity of the cerebral cortex.* Surprisingly, later reproductions of the original publication

leave off the subtitle suggesting, especially for the behaviorally focused western psychologists, that the focus of the book is about "Pavlovian conditioning" or a form of learning.

Similarly, in reviewing William James's book, *Psychology*, the first English language textbook in psychology, the Table of Contents similarly provide us where psychology was founded. The book is nothing more than an introduction to neuropsychology textbook. By chapter three focus is being placed on specific and important areas of the brain. Within the first few pages of that chapter, the basic concepts of cerebral hemispheres are outlined. Interestingly, the discoverer of the split brain phenomena and psychology's first Nobel Prize winner, Roger W. Sperry, was introduced to psychology both by this book and one of James' student.

The question remains; how is one to bridge the powerful origins of Russian and American psychology? Since the founding of psychology in the late 1800s, the distance between Russian and western psychology has been much larger than the geographic distance between the two.

The most likely person and theory to bring psychology back to its roots and to bridge the two historically competing perspectives is the romantic science of Alexander Luria. In doing so, three predictions are made:

1. The specialty of clinical neuropsychology, one of the largest, fastest growing and most important specializations in psychology, has yet to realize the value it can provide psychology and health. The gulf between medicine and psychology has been historically so wide that a Cartesian dualism has penetrated both the thinking of physicians and psychologists as well as even of the typical citizen in our societies. The idea of bringing the two perspectives from the east and the west, together will go a long ways in crossing this illusory gulf.
2. As our world(s) shrink and national boundaries become artificial and the interface between people(s) and culture(s) become the rule and not the exception, a socio-historical-contextual perspective becomes the sole solution to narrow, if not, completely eliminate the perceptual differences that have prevented more universal understanding and solutions. In doing so, neuropsychology then becomes the conduit for psychology to fill the gaps that historically powerful institutions have yet to address successfully.
3. The concept of a romantic science is the most robust approach to bridging the subjective with the objective, the qualitative with the quantitative, and ignorance with understanding. In interjecting the concept of a romantic science, the interfacing of historically and diametrically opposed paradigms brings forth new possibilities. In doing so, the hope and direction that has been missing in psychology may be restated.

As the 125th president of the American Psychological Association, I am honored and privileged to be part of the historical event — the founding of the Lurian Journal.

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## *Greetings From the Polish Society of Neuropsychology*

# Aleksander Romanowich Luria (1902–1977) and the Heritage of His Neuropsychological Thought in Poland

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## *Приветствие от Польского общества нейропсихологии*

# Александр Романович Лурия (1902–1977) и наследие его нейропсихологической мысли в Польше

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It is a great privilege and joy for me that I can write greetings to the Lurian Journal edited by Professor Janna Glozman and dedicated to the popularization of the scientific thought of the eminent Russian scientist Alexander Romanowicz Luria (Александр Романович Лурия). During more than 50 years of scientific work of A. R. Luria made a great contribution to the development of various fields of psychology, such as psycholinguistics, psychophysiology, developmental psychology, ethnopsychology, etc. He also contributed to the emergence of a new discipline of science — neuropsychology, as well as contributing to the development of cultural psychology and inspiring the emergence of the neuropsychology of creativity. Luria was one of the few Soviet scientists whose work was read and appreciated in the West. Many of his colleagues also have significant

scientific achievements. These include Bein (1964), Tsvetkova (1985), Akhutina (1975), Glozman (1999, 2012), Kaczmarek (1984, 2012), Kądzielawa (1986), Klimkowski (1975, 1976), Maruszewski (1966, 1974), and Tłokiński (1986) in Poland; Laaksonen (1986), Christensen (1975) in Denmark; Bisiach in Italy; Luzzatti (1978) in Finland; Brown (1988), Tonkonogy and Goodglass (1981), and Goldberg (2001) in the USA.

When discussing the beginnings of neuropsychology in Poland it is worth pointing out that Aleksandr R. Luria was the first scientist who defined neuropsychology as a science dealing with relationships between brain structures and mental activities. This approach to the subject of neuropsychology is associated with the traditions of the Russian psychophysiological school, which comprised many eminent researchers, enough to mention Pavlov, Anokhin and Bernstein. Luria creatively developed the concept of the "functional system" introduced by Anokhin. The most important feature of this system is not only its complex multilevel structure, but also its dynamic, plastic character. This means that it may undergo changes of both its components and general structure. Luria emphasized that such an organization of the brain was closely linked to higher cortical activities.

It is also worth recalling that Luria laid the foundations for the theory of a symptom. He emphasized that the symptom does not point directly to the place of brain damage, because it results from a disruption of the entire system. Therefore, in order to specify the real nature of the symptoms observed it is imperative to underpin the "basic defect" that leads to the appearance of the disorders. It is possible to delineate a syndrome specific to the "defect" that underline the syndrome. This type of assessment is known as syndromological analysis. It was commonly used in medical diagnosis and Luria modified it by including neuropsychological analysis of particular syndrome. In this way he has utilized his medical background. After all he did receive a doctorate in medicine.

Luria was born on July 16, 1902 in Kazan. His father, Roman Albertowich Luria, was a well-known and respected doctor, while his mother was a stomatologist. For the reader of the Lurian Journal, it may be interesting to note that the mother graduated from extramural studies in Poland, because at that time in Tsarist Russia, women were not admitted to universities. After passing the school-leaving certificate exam, A. R. Luria joined the Faculty of Social Sciences at the University of Kazan in 1918. He was to pass his examinations early and graduated in 1921.

His work on reaction time and related thought processes was well recognized and in 1923 he received a position at the Institute of Psychology in Moscow. From the beginning, Luria showed very wide interests, and was among others a founder of the students' Social Sciences Society. Not everyone knows that he organized a psychoanalytical circle when he worked as an assistant at the Institute of Labour Organization in Kazan. As a result of these interests he produced a book which was published in the United States under the title *The Nature of Human Conflicts* (Luria, 1932). The author describes in it attempts to study emotional states by registering motor and vascular reactions. In his mind, thanks to cooperation with Vygotsky, understanding is born from the relationship between the brain and mental activities.

In 1925, Luria visited Berlin, where he met, among others, Levin, Köhler and Goldstein, and in 1929 during the International Congress of Psychologists he met many American psychologists and the eminent linguist Roman Jakobson. This is how his interest in aphasia was born. However, particularly important for Luria's scientific activity was cooperation with Lev Vygotsky, whom he met in 1924. Psychological expeditions under Vygotsky to Central Asia in 1931–1932 aimed at an evaluation of the empirical verification of Vygotsky's assumptions as to the socio-cultural basis of human cognitive processes, including the impact of school education on thinking, perception, and memory. These studies met with harsh criticism on the part of the authorities at the time, as did Vygotsky's whole theory. In consequence, his supporters were forced to move from Moscow to Kharkov. Among the Kharkov group were such well known researchers as Leontiev, Zaporozhets, Elkonin, and Galperin.

After coming back to Moscow, Luria took a job at the Institute of Neurosurgery. Here he began to conduct research, which over time brought him worldwide fame and laid the foundation for a new field of scientific and clinical research — neuropsychology. During this time, he began medical studies and obtained a medical diploma in 1937.

His work in a hospital in the Urals in 1941 made possible extensive research in the field of neuropsychology on a wide base of clinical material. This was caused by the influx of wounded from the frontline in the battle against Nazi Germany. He had the opportunity to work with soldiers with gunshot wounds to the brain. This created the foundation for the development of knowledge about the functioning of the brain based on the disorders observed. Particularly important was the research on speech disorders, which resulted in the publication of the book *Post-traumatic Aphasia*. At that time Luria cooperated with many outstanding psychologists, such as Zeigarnik, Zaporozhets and Rubinstein, as well as neurologists — Perelman and Basin.

In 1944, Luria returned to work at the Institute of Neurosurgery in Moscow. Starting from 1945 he also worked at Moscow State University and was instrumental in establishing the Faculty of Psychology at this university, where he later headed the Institute of Pathology and Neuropsychology. However, he was removed from in 1950 on the basis of the fact that his theory was not compatible with Pavlov's teaching. Luria then took a job at the Institute of Defectology, which resulted in work on the importance of language for child development. This applies especially to the regulating function of speech as developed later in Poland in the therapy of behavioural disorders in people with brain damage. In 1956 Luria returned to neuropsychology. He made contacts with many prominent psychologists from abroad, including J. Piaget, J. Bruner, W. Janus, W. Cannon, K. Pribram, and J. W. Brown. He also received many invitations and in 1960 he visited the United States. Later, many of his students and friends visited him in Moscow.

Both in his early neuropsychological work at the end of the 1830s as well as throughout his post-war academic career, Luria focused on research into aphasia, focusing on the relationship between language, *thinking* and cortical functions, especially on the development of compensatory mechanisms in aphasia.

Two main case studies were to have an impact on the work of Polish neuropsychologists; these being published a few years before his death. This is the case of the Russian journalist S. V. Shereshevski, with seemingly unlimited memory, partly due to the occurrence of the phenomenon of synesthesia. This case was presented in the book *On Memory, which had no limits*. Another known book by Luria and also translated into Polish is the *Man with a shattered world,* which presents the poignant case study of Zasetsky, a young man who suffered a brain injury as a result of a gunshot wound. These examples illustrate Luria's main working methods, combining classic and remedial approaches. They were widely discussed and served as inspiration when developing two textbooks on neuropsychology published in Poland.

A special friendship connected Luria with Jason W. Brown, who remains in close contact with Polish neuropsychologists. This friendship began during Brown's long stay in Moscow in 1976. These scholars then carried out lively correspondence, sharing their insights on brain function and on methods of treating patients after brain injuries. Many of these methods were implemented in patient therapy at the Center for Cognition and Communication founded at the time by Professor Brown in New York. The clients of this center, at which the first author of this note has been a consultant for several years, were and still are mainly patients after brain injuries. Luria's cooperation with Brown has, among others, contributed to the emergence of microgenetic theory, introduced into clinical practice in Poland and successfully under development until now.

Luria and Polish neuropsychologists have also been in close contact and friendship. First this involved his immediate students: Mariusz Maruszewski, Marcel Klimkowski and Bożydar L. J. Kaczmarek. They created neuropsychological schools at the University of Warsaw and the Lublin based Maria Curie-Sklodowska University as well as neurolinguistics. These activities are still being developed by students of these scholars.

Luria's activities in Poland have been highlighted in a special way. He receives the title of Doctor Honoris Causa of the Maria Curie-Sklodowska Lublin University in 1974 from the hands of the rector of The Maria Curie-Skłodowska University, Prof. Wiesław Skrzydło (see *Figure 1*).

A special Polish accent recognizing this scholar is the jubilee issue of the international periodical Aphasiology, whose editor was Prof. Bożydar L. J. Kaczmarek. The value of this publication is that, in contrast to other works of this type, it presents the works of Luria students both from the field of Western neuropsychology as well as from the former Socialist Bloc.

Among Luria's Polish friends was also Maria Susułowska of the Jagiellonian University's Institute of Psychology. During Luria's visit to Krakow and in warm correspondence, both scientists emphasized the importance of the in-depth study of individual cases as opposed to the ever-growing interest in group research. The discussion particularly included the phenomenon that the same brain damage has a different impact on the lives of different people. For example, a disorder of musical hearing is a great problem for a professional musician, while speech disorders are the tragedy of a lawyer or a teacher. It is worth adding that Susułowska was a lover of music and this observation could be influenced by

*Figure 1*. Alexander R. Luria (right) receives the title of Doctor Honoris Causa in 1974 from the hands of the rector of The Maria Curie-Skłodowska University, Prof. Wiesław Skrzydło. From Pąchalska, Kaczmarek, & Kropotov, 2014

their joint visits to concerts at the Krakow Philharmonic Concert Hall. It is also highly probable that these conversations allowed Luria to realize how great the impact of brain damage on a patient's entire life is: on its cognitive, emotional and professional aspects.

Lurian approach to the problem of the localization of the higher mental functions is widely developed in Poland. According to the said:

> …higher mental functions as complex functional systems cannot be located in narrow zones of the cerebral cortex or in isolated groups of cells, on the basis of complex systems of jointly operating zones, each of which contribute to the implementation of complex mental processes and which can be located in completely different, sometimes distant parts of the brain (Fundamentals of Neuropsychology, 2014, chap. 2, p. 3).

This finds its confirmation in the discovery of previously unknown forms of speech disorders beside those described by Luria as a result of new neurotechnologies. Of particular significance are neuromarkers enabling the precise diagnosis of brain disorders with the use of quantitative electroencephalography (qEEG) and Event Related Potentials (ERPs).

In recognition of this immense contribution to the development of Polish neuropsychology, the long-term President of the Polish Neuropsychological Society — Prof. Maria

Pąchalska — honoured Luria, posthumously, with its highest award — The Copernicus Prize 2002 (see *Figure 2*). This took place during the International Congress of Neuropsychology in Moscow on the occasion of the 100th anniversary of Luria's birth.

In Poland, we teach our students the Lurian approach. They also know that the Russian School organized several congresses devoted to Alexander R. Luria. The Congress on the 110th anniversary of Luria's birth in 2012 turned out to be a great scientific success. First of all, it showed that the Russian school of neuropsychology is still important and that Luria's ideas are still valid. It is not surprising then that many well-known neuroscientists from both Russia and around the world actively participated in the congress. In the satellite conference a lively discussion was conducted, involving, among others, such famous researchers as Michael Cole, Elkhonon Goldberg, and Antonio Puente. Moreover, a Memorial Plaque was unveiled there, while one of the lecture halls at the Institute of Psychology at the Lomonosov University in Moscow was named The Alexander R. Luria Auditorium. At the same time presented was an interesting exhibition of Luria's achievements.

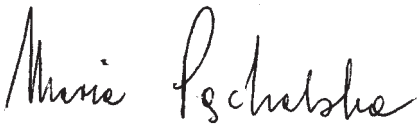
Above of all, the congress contributed to the founding, by Professor Janna Glozman, of the Society of Applied Neuroscience (SAN) with significant support from the President of the Polish Society of Neuropsychology Professor Maria Pąchalska, and at the same time


*Figure 2.* The highest award of the Polish Neuropsychological Association — The Copernicus Prize 2002 — posthumously presented to mark the 100th anniversary of the birth of A. R. Luria. S o u r c e: the library of M. Pąchalska

a representatives of the International Society of Neuropsychology. The members of the society are not only renowned Russian scientists as well as young researchers, both from Moscow and other areas of Russia, starting from St. Petersburg and ending in Kamchatka, but also scholars from all over the world. The functions of society vice-president are held by Prof. Maria Pąchalska and Prof. Bożydar Kaczmarek.

The Journal *Acta Neuropsychologica*, published in Poland by MEDSPORTPRESS and edited by Maria Pąchalska, has popularized both the achievements of Alexander Romanovich Luria and the Russian school of neuropsychology by publishing many scientific articles, and when needed, other reports on significant scientific events devoted to the popularization of the Lurian approach. The heritage of Luria's neuropsychological thought is great. Speaking as Horace, he built a work more durable than bronze [Exegi monumentum aere perennius]. His scientific thought has inspired and continues to inspire many scholars in the world. These are not only his students and colleagues, but also their scientific descendants.

I would like to express my deepest congratulations and good wishes to Professor Janna Glozman for continuing this immortal work in the *Lurian Journal*.



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# RESEARCH PAPERS

# НАУЧНЫЕ ИССЛЕДОВАНИЯ

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# Neuropsychology in the Past, Now and in the Future

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# Нейропсихология вчера, сегодня, завтра

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The actual intensive and extensive growth of international neuropsychology (both theoretical and applied) testified in the paper, is due to the abilities of contemporary professional neuropsychologists to meet different purposes beyond understanding of brain-behavior relationships. It makes contemporary neuropsychology an important part of the psychology of health, instead to be an aspect of the biology of health.

The value and the history of Lurian syndrome analysis are presented. The Lurian syndrome analysis (a qualitative (structural) analysis of the symptom under study), not only permits an understanding of why the subject was poor at or unable to perform a given task. Such an approach also allows us to see what other tasks, with similar cognitive demands (structure), could present difficulties for this individual (child or adult) as well as to predict the types of tasks accessible for the patient and the types of cueing efficient for him/her. The last is possible in conditions of dialogue interaction with the patient in the process of neuropsychological assessment. Lurian approach is oriented on the process of test fulfilment (the means by which the performer achieves or better the result as well as the level of necessary help or stimulation), more than on the test result — the level of performance on a task (accuracy, time, number of mistakes and so on) with reference to some expected (normative) level of performance.

The evolution of neuropsychology coincides with the universal tendency to replace a static neuropsychology, relating the individual's behavior to fixed cerebral lesions, by a dynamic neuropsychology, which analyzes the dynamics of brain-behavior interaction in different social conditions and at different steps of ontogenic evolution. The author gives own model of neuropsychology evolution, including three overlapping and coexisting phases different in the main emphasis for neuropsychologists. In the first phase, the accent was on the brain and its relationship to different behaviors. In the second phase of neuropsychology evolution the structure

of mental activity and neuropsychological interpretation of human cognition have been the focus of attention and afterwards their localization in the brain. The third and actually dominant phase of evolution in neuropsychology focuses on the interrelationship between a patient and his or her environment and integrates neuropsychological and real life data. This phase gave birth to social — historical or cultural — historical neuropsychology. One of the important consequences of cultural — historical approach in neuropsychology was the introduction of cultural adjustments in neuropsychological diagnostic tests, both verbal and nonverbal.

Qualitative and quantitative integration of Lurian procedures are discussed. Underlined are differences in concepts *neuropsychology* and *neurosciences*, as well as the role of cultural-historical approach in contemporary neuropsychological assessment, rehabilitation and remediation.

Three main trends can be seen in the evolution of neuropsychology after Luria: 1. Extensive further expansion of research and practice, that is, embracing numerous new domains and nosological patient groups; 2. Combination of qualitative and quantitative approaches; 3. Social and personality-based orientation.

Luria's creative and comprehensive approach stimulates the further evolution of neuropsychology in Russia and throughout the world.

***Keywords*****:** *neuropsychology; its purposes; phases of evolution; syndrome analysis; A. R. Luria; cultural neuropsychology.*

Интенсивный и экстенсивный рост нейропсихологических методов исследований (как теоретических, так и прикладных) во всем мире в последние десятилетия объясняется тем, что современный нейропсихолог может решать задачи, далеко выходящие за рамки изучения связи мозга и психики. Современная нейропсихология из аспекта биологии здоровья стала важнейшим компонентом психологии здоровья.

В статье показаны история создания луриевского синдромного анализа и его значение для нейропсихологии. Луриевский подход (качественный, структурный анализ наблюдаемого симптома) позволяет не только понять, почему пациент не справляется с выполнением предложенного нейропсихологического теста или затрудняется его выполнить, но и предсказать, какие задачи со сходной психологической структурой будут трудны для данного пациента (как взрослого, так и ребенка), а какие будут ему доступны, и какие виды помощи нейропсихолога эффективны в условиях диалогового взаимодействия при нейропсихологической диагностике. Луриевский подход предполагает ориентацию в большей степени на процесс выполнения теста и анализ видов помощи экспериментатора, позволяющих достичь или улучшить результат, чем на сам результат (точность, время, число ошибок) с учетом нормативных данных.

Развитие нейропсихологии связано с общей тенденцией к замене статической нейропсихологии, жестко связывающей поведение индивидуума с определенными областями мозга, динамической нейропсихологией, изучающей взаимодействие мозга и психики на разных этапах онтогенеза и в различных социальных условиях. Проанализирована динамика развития нейропсихологии, дана авторская модель ее развития как континуума из трех взаимосвязанных этапов. На первом этапе в центре внимания

нейропсихологов было взаимодействие мозга и различных форм поведения, на втором — структура психических процессов и нейропсихологическая характеристика познания. На третьем, в настоящее время ведущем этапе развития нейропсихологии акцент исследователей сместился на взаимодействие больного с окружающим миром, с реальными условиями его жизнедеятельности. На этом этапе возникла культурно-историческая (социально-историческая) нейропсихология. Важным достижением культурно-исторического подхода в нейропсихологии являются разработка и внедрение культурно-специфических методов в нейропсихологическую диагностику.

Обсуждаются возможности интеграции качественного и количественного подхода в нейропсихологической диагностике. Подчеркиваются неоднозначность и различия понятий *нейропсихологии* и *нейронауки* и роль культурно-исторического подхода в современной нейропсихологической диагностике, реабилитации и коррекции.

Можно выделить три основные характеристики развития нейропсихологии после Лурия: 1) экстенсивное распространение нейропсихологической диагностики на новые нозологические группы больных и новые области исследований; 2) сочетание качественного и количественного подхода; 3) социально-личностная ориентация.

Луриевский подход, отличающийся многосторонностью и креативностью, продолжает стимулировать развитие нейропсихологии как в России, так и за рубежом.

***Ключевые слова:*** *нейропсихология; этапы развития нейропсихологии; синдромный анализ; А. Р. Лурия; культурно-историческая нейропсихология.*

## The Growth of Neuropsychology (Historical Introduction)

The second half of the XX century and beginning of XXI century have witnessed phenomenal growth of both theoretical and applied neuropsychology. Many evidences testify this growth:

1. Creation of *specialty divisions* in most National Psychological Associations.
2. Creation of *National Neuropsychological Societies,* such as, the Sociedad Latinoamericana de Neuropsicología (SLAN), the South African Clinical Neuropsychological Association (SACNA), Polish Neuropsychological Society, the Australasian Society for the Study of Brain Impairment (ASSBI) and more.
3. The *International Neuropsychological Society* (INS) was established in 1967 in the USA with only a few members (Rourke & Murji, 2000), with its membership growing to about 5,000 by 2015. Its first president was Karl H. Pribram. The Journal of the International Neuropsychological Society (its official journal), is currently published ten times per year. INS holds two meetings each year. Over the past five years, the Annual Meeting has averaged approximately 1700 attendees per year.
4. *Federation of European Societies of Neuropsychology (FESN)* was created in 2008 and unifies the neuropsychological societies of Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Italy, Luxemburg, Nether-

lands, Norway, Poland, Portugal, Spain, Sweden Switzerland, Turkey, and United Kingdom with biennial scientific conferences.

5. *International Society of Applied Neuropsychology (ISAN)* was established in 2016 in Barcelona, to contribute to the progress in neuropsychological assessment and rehabilitation of children and adults with disturbances (underdevelopment) of cognitive functioning, personality and behavior as well as to increase in quality of training of specialists in applied neuropsychology.

This international growth is due to the abilities of contemporary professional neuropsychologists to meet different purposes beyond understanding of brain-behavior relationships (Luria, 1965, 1969; Korsakova & Glozman, 1986; Glozman, 1999a, 2012; Homskaya, 2005):

1. Neuropsychological study of normal and abnormal mental functioning.
2. Focal diagnosis of the brain damage underlying observed defects of mental functioning.
3. Differential diagnosis between organic and socio-psychological etiologies of disturbances.
4. Comprehensive description of impairments of higher mental functions and the identification of the factors underlying such impairments.
5. Prediction and prevention of social manifestations and consequences of higher mental function disturbances, such as learning disabilities, school maladjustment and others.
6. Neuropsychological study of individual differences.
7. Evolution of individual treatment plans and strategies for remediation of cognitive disorders.
8. Evaluation of the outcome of different kinds of treatment: surgical, pharmacological, psychological, and others.
9. Determination of the best methods of treatment for different cases (both children and adults).

This list can be continued:

> It is probable; however, that neurodiagnostic evaluation by neuropsychologists will prove to be less important than the ability to specify precisely behavioral deficits and strengths. Perhaps most important will be the neuropsychologist's ability to propose precise training programs for motor, sensory and cognitive deficits (Wedding, Horton, & Webster, 1986, p. ix).

The revealed behavioral deficits orient the rehabilitation program while the revealed strengths determine the strategy of training. The final task is to meet "the challenge of alleviating human distress and promoting social well-being for the brain-impaired population" (Ibid., p. x).

Thus, we see both the variety of tasks successively solved by contemporary neuropsychology, as well as the dynamics in their relative importance. Let us describe now the actual state of theoretical and applied neuropsychology.

The neuropsychology shows now both *intensive and extensive development*, as proven by the increased number of neuropsychological techniques and by the extended sphere of their application, not only in neurosurgery and neurology but also in psychiatry, gerontology, the somatic clinic, in normal and special education, etc. (Korsakova, 1998; Glozman, 1999b).

> Neuropsychology can provide valuable understanding in the treatment of such chronic diseases as lupus, chronic obstructive lung diseases (emphysema), cardiovascular disorders, and certain types of oncological disorders…In this respect, any medical complication or treatment having a direct or indirect impact on neural integrity should be considered within the scope of neuropsychology (Horton & Puente, 1986, p. 18).

Neuropsychological consequences appear after different diseases or deviated evolution. It makes neuropsychology the important part of the psychology of health (Ryan, Vega, Longstreet, & Drash, 1984).

Let us speak further about neuropsychological techniques or tests. Their history passed a long way from description of revealed symptoms to their scoring and then from scoring to their analysis (see details in Glozman, 2012). Neuropsychological tests differ in specificity and sensitivity. Highly specific tests help to make a diagnosis, whereas highly sensitive tests can refute a diagnosis (Smith, Ivnik, & Lucas, 2008).

The evolution of neuroimaging techniques (MRI, CT, PET), beginning in the late 1960s, does not decrease the diagnostic value of neuropsychological assessment in neurology and neurosurgery. "As exciting as these new diagnostic techniques are, they still fail (because of (the) inherent aspects of the technology) to provide an adequate presentation of human behavior" (Horton & Puente, 1986, p. 18). Luria wrote:

> I am inclined to strongly reject an approach in which these auxiliary aids become the central method and in which their role as servant to clinical thought is reversed so that clinical reasoning follows instrumental data as a slave follows its master (Cole, Levitin, & Luria, 2006, p. 177).

An important diagnostic task is to reveal disorders of higher mental functions in cases where cerebral organic disturbances are not evident (for instance, after toxic injuries or vascular dysfunctions, or mental delay in children). Early neuropsychological diagnosis of mental dysfunctions (in preschool age or at the initial phases of disease) helps to prevent an aggravation of defects and to select the most efficient methods of surmounting defects. It was proven that a remediation of learning-disabled children is more effective when it is based on neuropsychological assessment data (Hartlage, 1975; Akhutina & Pylayeva, 2008; Glozman, 2013).

Therefore, the neuropsychological assessment has *differential diagnostic, remediative, preventive, and prognostic aspects.*

In order to achieve these purposes, according to Luria:

> Neuropsychological assessment must not be limited to a simple statement that one or another form of mental activity is below level. The investigation must be always a qualitative (structural) analysis of the symptom under study, specifying the observed defect, its possible character, and the factors causing it (Luria, 1969, p. 306).

For example, it is well known that most patients with brain disturbance (both organic and functional) complain of memory troubles. "But, this 'memory trouble' can be provoked by different causes. It is natural that we should precise with special methods the structure and the meaning of this symptom to qualify it and the underlying factors" (Ibid., p. 303). A. R. Luria has named such an approach the *syndrome analysis*.

To understand the value of this approach one should look in the history of neuropsychology.

## The History of Neuropsychology

It was stated, that neuropsychology has "a long past, but a short history" (Horton & Puente, 1986, p. 3).

Neuropsychology started by descriptions by neurologists and psychiatrists of individual cases with mental function disturbances (predominantly speech and memory) with attempts to relate them to an injury of definite brain areas. Such first attempts date as far back as 3000–2550 BCE (Walsh, 1978). At the end of the 16th and the beginning of the 17th centuries, some observations on localization of mental functions appeared in the works of René Descartes, but a real explosion of such observations in all countries was due to autopsy legalization in the 19th century medicine: P. Broca, 1861; C. Wernicke, 1874; A. Ya. Kojevnikov, 1874; S. S. Korsakov, 1887; K. Goldstein, 1925; K. Lasley, 1929; M. B. Krol, 1934; A. R. Luria, 1947; R. Reitan, 1955; R. Sperry, 1961; M. Gazzaniga, 1970 (see details and references in Glozman, 2012). It was the period of big discussions in international neurological literature between followers of localizationism (brain is an aggregate of "Centers" each of which is related to a particular function) and of antilocalizationism (brain is equipotential, that is it realizes all mental function as a whole). The discussion stopped when Luria has created his theory of dynamic and systematic cerebral organization of mental processes. It means that each mental function is based on the integrative functioning of different brain regions united in brain functional systems. With this, "the structure of the organism presupposes not an accidental mosaic, but a complex organization of separate systems. This organization is expressed paramountly in a functional correlation of these systems… they unite as very definite parts into an integrated functional structure" (Luria, 1932, pp. 6–7).

This Luria's idea has been integrated into contemporary neuropsychology and cognitive neurosciences. Today it is considered as a basic idea, not as a specific author's pro-

posal. Contemporary brain research has emphasized that brain systems or brain circuits realize cognitive processes. Therefore, a disturbance of the same higher mental function (like speech or memory) may be revealed when different brain areas are damaged. It necessitates a specific procedure of neuropsychological assessment.

Luria describes the neuropsychological assessment in the following way:

> In experimental work a scholar usually begins by *choosing a specific problem.* Then he constructs *a hypothesis* and selects methods for testing his hypothesis. He arranges matters so that he can more easily focus his attention on those facts that will prove or disprove it. He is able to *ignore all data that do not contribute to his analysis* of the problem and to the proof of his hypothesis.
>
> By contrast, in **clinical work**, the starting point is not a clearly defined problem but an ***unknown bundle of problems*** and resources: ***the patient***. The clinical investigator begins by making careful observations of the patient in an effort to discover the crucial facts. In the beginning he ***can ignore nothing.*** Even data that on the first glance seem insignificant may turn out to be essential. At some point the ***vague contours of factors that seem important begin to emerge, and the clinician forms a tentative hypothesis about the problem.*** But it is still too early for him to say definitively whether the facts he has picked out are important to the problem or extraneous. Only when he has found ***a sufficient number of compatible symptoms that together form a "syndrome"*** he has a right to believe that his ***hypothesis about the patient might be proved or rejected*** (Luria, 1979/1982, p. 132, bolded by J. Glozman).

So, Lurian neuropsychological assessment is an individualized assessment of disturbances, that presupposes a qualitative estimation of symptoms, i. e. detecting a primary deficit, its systemic consequences and compensatory reorganization.

The Lurian syndrome analysis not only permits an understanding of why the subject was poor at or unable to perform a given task, but it also allows us to see what other tasks, with similar cognitive demands (structure), could present difficulties for this individual. Even more important is ability of Lurian approach to predict the types of tasks accessible for the patient and the types of cueing efficient for him/her in conditions of dialogue interaction with the patient during neuropsychological assessment. In other words, Lurian approach is oriented on the process of test fulfilment (the means by which the performer achieves or better the result or the level of necessary help or stimulation), more than on the test result — the level of performance on a task (accuracy, time, number of mistakes and so on) with reference to some expected (normative) level of performance.

> Thus, qualitative analysis, or psychological qualification of the deficit, includes two main points. First, determining what is characteristic and specific for a particular symptom and what differentiates it from other known symptoms capable of disturbing the same mental function. Second, pinpointing the common "factor" that associates symptoms of different mental function disturbances arisen as a result of brain damage (Mikadze, Ardila, & Akhutina, 2019, p. 796).

It permits both: a better understanding of patient's problems and the selection of appropriate methods of his/her rehabilitation.

The *figure 1* illustrates the specific features of Lurian assessment.

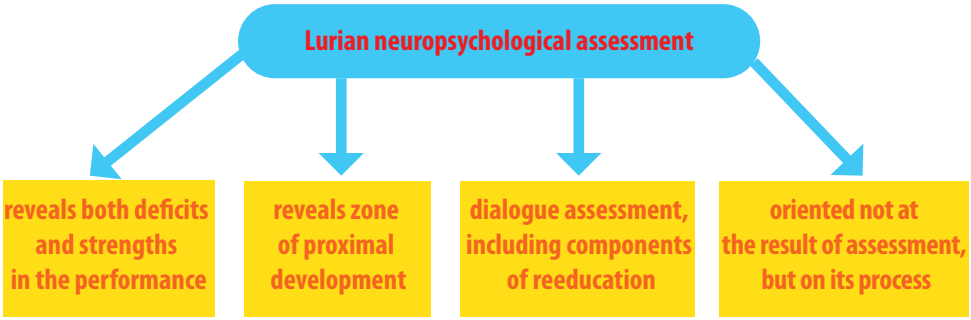


*Figure 1.* Specific features of Lurian assessment

## Definitions of Neuropsychology and its Evolution

The field of the word *neuropsychology* includes as synonyms cognitive neuropsychology, clinical neuropsychology, behavioral neurology and behavioral neuropsychology, experimental neuropsychology, neurosciences, physiological psychology and more. From the other side, neuropsychology enters in the semantic field of neurosciences together with neuroimaging, neurophysiology, cognitive neurosciences, neuroanatomy, neurobiology, neurogenetics, neurochemistry and even neuro-economics. Therefore, different authors have advanced multiple definitions of neuropsychology. The most popular is the definition by M. Meier (1974): "Neuropsychology is the scientific study of brain-behavior relationship" (cited by Horton and Puente, 1986, p. 5). According to Horton and Puente (1986) this definition addresses the most fields of neuropsychology, but it fails to address the new field of behavioral neurology and neuropsychology, which utilizes a qualitative approach to the conceptualization of neurobehavioral phenomena. The difference between behavioral neurology and behavioral neuropsychology, according to Horton (1979) is in the treatment philosophy of the last, that is the major emphasis upon the problems of rehabilitation, reinforcement. Very close to Luria's approach are the ideas that "inclusion of data from neuropsychological assessment strategies would be helpful in the formulation of hypotheses regarding antecedent conditions (external or internal) for observed phenomena of psychopathology" (Horton, 1979, p. 20). With this the "inherent variables, such as thoughts and images should be seen as legitimate concepts in the functional analysis of human behavior" (Horton & Puente, 1986, p. 7).

The definition by Meier is very close to that done by A. R. Luria (1973), but being a founder of applied fields of neuropsychology, he added to this definition "a study of possibilities to use this knowledge for early and precise neuropsychological assessment and scientifically based rehabilitation of functions" (Luria, 1973, p. 10). It approaches Luria's

definition to that of behavioral neuropsychology. Change in terms and concepts "is a fact of life that is more salient with each passing day" (Horton & Puente, 1986, p. 19).

The evolution of neuropsychology conceptualizing and definition coincides with the universal tendency to replace a static neuropsychology, relating the individual's behavior to fixed cerebral lesions, by a dynamic neuropsychology, which analyzes the dynamics of brain-behavior interaction (Tupper & Cicerone, 1990; Glozman, 1999a, 2007). The following model represents this evolution in neuropsychology through three overlapping and coexisting phases, different in the main emphasis for neuropsychologists (see *Figure 2*).

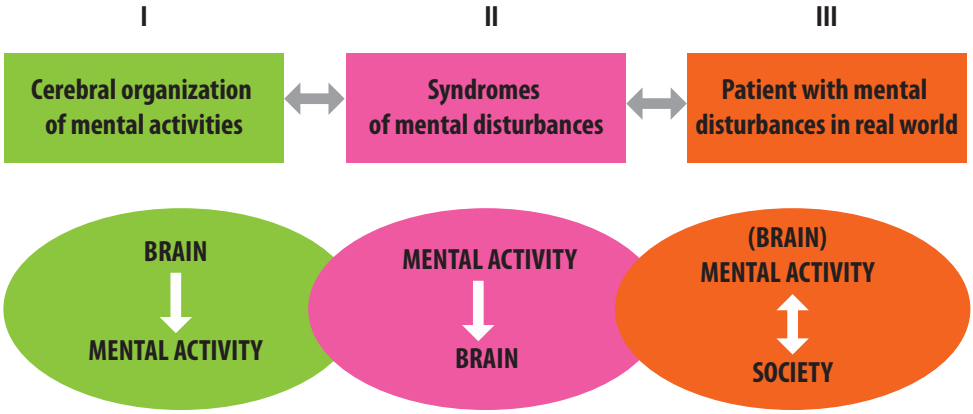


*Figure 2.* Model of evolution in neuropsychology

In the *first phase*, the emphasis for neuropsychologists was on the brain and its relationship to different behaviors. The above definition of neuropsychology (brain-behavior relationships) is relevant to this first phase in neuropsychology evolution.

The neuropsychology of this period was considered by Luria, as well as by occidental neuropsychologists, to be a "field of practical medicine" (Luria, 1973, p. 17). The main and most valuable attainment of this phase is a revision by Luria of concepts of localizationism and antilocalizationism and the creation of the theory of the dynamic and systematic cerebral organization of mental processes. This progress resulted in the functional analysis of different brain systems and description of frontal, parietal, temporal, and other syndromes. The recent evolution of this approach follows three main lines:

1. Study of functions of the right hemisphere and interhemispheric interactions for different types of memory, perception, and reasoning.
2. Research in subcortical brain pathology.
3. Studies of cerebral mechanisms of mental, neurotic and somatic diseases.

In the *second phase* of neuropsychology evolution, the *structure* of each mental activity has been the focus of attention and afterwards its localization in the brain. "Although Luria's interpretation of human cognition was proposed several decades ago… new scientific and technological advances have in large measure supported many of his ideas and hypotheses". (Kotik-Friedgut & Ardila, 2019, p. 2). The second phase gave birth to different syndromes of mental disturbances: local, resulting in neuropsychology of memory (Luria, 1976a),

neurolinguistics (Luria, 1976b); diffuse syndromes after cerebral vascular pathology (Moskovich, 2004), syndromes of underdevelopment or not typical development, resulting in learning disabilities (Glozman, 2013); and also cognitive dysfunctions in normal subjects in specific functional states or with some individual particularities or accentuations in cognitive performances. This last line gave birth to neuropsychology of individual differences, which is an application of neuropsychological concepts and methods to the assessment of healthy subjects (Homskaya, Efimova, Budyka, & Enikolopova, 1997).

*The third and actually dominant phase* of evolution in neuropsychology focuses on the interrelationship between a patient and his or her environment and integrates neuropsychological and real life data. It gave birth to new branches of neuropsychology: ecological neuropsychology: behavioral neuropsychology, neuropsychology of everyday life, neuropsychology of personality and communication, neuropsychology of family.

Many standardized neuropsychological measures have been criticized for poor ecological validity, that is they don't reflect patient's abilities in daily activity.

> Ecological methods were created to allow for assessment of the mental and emotional state of the subjects using tests and questionnaires which provide quantitative estimation of frequent behaviors (functional status), and predicts possible daily life problems of a patient. Results are presented in the form of data pointing to the disturbance of certain behaviors instrumental for adaptation to social situation, daily life, and independent functioning (Mikadze et al., 2019, p. 797).

The emphasis of the assessments is now a shift from diagnostic evaluation to prognostic and corrective suggestions. The neuropsychological assessment should emphasize the subject's strengths, which are important in his/her correction (rehabilitation) program and predict his/her ultimate adaptation and integration into society.

Such an understanding is based on *the Lurian patient centered approaches in neuropsychological assessment and rehabilitation,* that is, the primary focus on the experience of individuals, their subjective interpretation and personal knowledge of health and disease, their coping strategies, self-esteem, emotional well-being and social interaction. The person-centered approach have long been considered as lacking scientific rigor, but it is becoming now more and more recognized. It permits to explain, why people who apparently are exposed to the same damages, who even cope in similar ways and have equivalent social support have different degree of strain and depression and different outcome after rehabilitation. From the person-centered view Quality of Life means the perception and evaluation by the patient (her or himself) of the impact that the disease and its consequences have produced in her/his life. The optimal Quality of Life is the patient's self-satisfaction with the mental and physical features of own life and the results of the rehabilitation program.

These ideas predominant at the third phase of neuropsychology evolution prepared its transformation in social-historical or cultural-historical neuropsychology. Both terms are used as synonyms in the literature.

## Social-Historical Neuropsychology

Vygotsky and Luria developed the idea that cognitive processes descend from complex *interaction and interdependence between biological factors* (the individual mind), which is part of physical nature, *and cultural factors*, which appear in the evolution of a human being. This *social-historical approach in neuropsychology* looks for the origins of human conscience and mental activity not inside the brain, nor in the mechanisms of nervous processes, but in the context of human social life.

> We need to step outside the organism to discover the sources of specifically human forms of psychological activity and the way natural processes such as physical maturation and sensory mechanisms become intertwined with culturally determined processes to produce the psychological functions of adults (Luria, 1979/1982, p. 43).

The experimental proves of these ideas about culture, especially schooling as a determinant of cognitive processes were received in famous expeditions of Luria to Uzbekistan during 1931 and 1932, which were planned and analyzed in cooperation with Lev Vygotsky.

Scribner and Cole (1978), Gilbert (1986) partially replicated Luria's field studies in South Africa with near-identical results. Later on, Tulviste (1991), Glozman (2018) also found similar results.

The role of Luria in the development of social-historical psychology was underlined by Vasily Davydov, former Director of Moscow Psychological Institute:

> An analysis of theoretical and methodological works by Luria (particularly his last works) proves, that he could not imagine another psychology than social-historical looking for origins of human conscience not inside the brain, not in the mechanisms of nervous processes but in the human social life — the real base for conscious activity (Davydov, 1998, p. 14–15).

The same was said by Jerome Bruner: "For Luria the brain was an instrument for making culture accessible to mind. …for him the 'internalization of culture' was a mastering of possible worlds" (Bruner, 2005, p. XII).

One of the important consequences of cultural-historical approach in neuropsychology was the introduction of cultural adjustments in neuropsychological diagnostic tests, both verbal and nonverbal (Nell, 2000; Agranovich, 2004; Nielsen et al., 2018). All norms for neuropsychological tests should be culture specific to provide their reliability. Standard procedure of test administration does not provide its relevance to culture standards. A test translation to another language needs a selection of a new material corresponding to linguistic and cultural features. Cultural specificity of neuropsychological assessment is both social and ethical problem. Cultural equality of tests is as important as their statistical validity for assessment of mental functioning.

Another application of cultural-historical approach in neuropsychology are researches of social brain. The term *social brain* was introduced in neuropsychology by M. Gazzaniga (1985) in his studies of emotional and social communication disturbances after right hemisphere damages. Later this term was used to show how human brain processes the social information and determines the mind as a whole (Brüne, Ribbert, & Schiefenhovel, 2003; Insel & Fernald, 2004; Dunbar, Gamble, & Gowlett, 2010).

The relation between social cognition and social behavior are still largely unknown, or very complex and involved in connections with other regulatory processes. It is highly probable, that there is no simple translation of social cognition into social behavior. Nevertheless, pathology of those two components leads to interpersonal maladjustment of patients with brain injury. "Cultural-historical approach in neuropsychology means a change in social brain study orientation from localization to problems of social and cultural regulation of cerebral functions" (Glozman & Krukov, 2013, p. 77).

The cultural-historical approach in neuropsychology influenced also the neuroscience up to appearance of a new field of research — cultural neuroscience concerned with studying the influences of culture on brain anatomy and function (Chiao & Blizinsky, 2016). A. Toomela (1996) even postulated that culture transforms brain. It can be explained by the *law of double interaction between the brain maturation and the formation of the mental functions* determined by P. Ya. Halperin (a friend and colleague of Luria): on the one hand, for the emergence of a function a certain degree of maturity of the nervous system is required, on the other, the very functioning and the active and developing remedial effect influence the maturation of structural elements of the brain (Halperin, Zaporozhets, & Karpova, 1978). Lurian theory of higher mental functions formation well explains this law of morphological and functional interaction: "They [mental functions, J. G.] were all formed in the course of long historical development; they are social in their origin" (Luria, 1973, p. 29). Luria shared Vygotsky's "principle of extracortical organization of complex mental functions… implying… that all types of human conscious activity are always formed with the support of external auxiliary aids" (Luria, 1973, p. 31). The environment and surrounding people determine child cognitive development. Vice versa, child abuse has negative effect on his/her brain development (Perry, 2002).

> However, different mediators and means, or significantly different details within them (e. g., the direction of writing and the degree of letter sound correspondence, orientation by maps, digital internet navigator, or by the behavior of sea-birds) may be developed, and in fact are developed in different cultures. Therefore, the analysis of higher mental functions must necessarily take into account these cross-cultural differences (Kotik-Friedgut & Ardila, 2019, p. 2).

Consequently, to foresee how the technological advances can impact the development of the higher mental functions, therefore the neuropsychology of 21st century must incorporate the environmental changes (Ardila, 2013).

It is especially evident in works dealing with theory and practice of neuropsychological rehabilitation.

## Neuropsychological Rehabilitation

During the 21st century, neuropsychological rehabilitation has become one of the major areas in neuropsychology professional activity [e. g., Evans, Gast, Perdices, and Manolov (2014); Sohlberg and Mateer (2017)].

In "Traumatic aphasia" (Luria, 1947/1970) and "Restoration of functions after brain injury" (Luria, 1948/1963) Luria described two main strategies of higher mental functions rehabilitation: disinhibition of inhibited functional components, and reorganization of the affected functional systems, using inter- and intra-system functional restructuring.

Vygotsky wrote:

> Initially all these functions (higher forms of speech, cognition, and action) operate in intimate connections with external activity and only later on change into the inner activity. Research into compensatory functions which develop in these disorders also shows that objectification of a disturbed function, i. e. bringing it outside and changing it into external activity, is one of the basic roads in the compensation of disorders (Vygotsky, 1997, p. 143).

This principle was first realized in aphasiology as the so-called *socio-psychological aspect of rehabilitation*, studying social relationship between patient and other members of the therapeutic group (Tsvetkova, Glozman, Kalita, Maximenko, & Tsyganok, 1979), as well as changes derived from relationship between therapist and patient (Quintino-Aires, 2005), then in studies of interrelations between communication disorders and personality in different nosological groups (Glozman, 2004) and in developmental neuropsychology (Glozman, 2013).

> The optimal organization of communication within the therapy group provides the conditions for the mobilization of creative activity in the patient's mental sphere, personality and aids the growth of one's self-perception and "mental growth"… *The internal (the subject) acts trough the external and in doing so, changes itself* (Glozman, 2004, pp. 148–149).

Through internalization (Vygotsky, 1997), interpsychological (social/relational) forms are transferred to the intrapsychological (personal) forms of meaning.

The cultural-historical approach in neuropsychological rehabilitation of brain damaged patients and in remediation of learning disable children consists in further development of the theory of *mediation.* During the late 1920's — early 1930th Luria and Vygotsky tried to rehabilitate Parkinsonian patients in the laboratory of neuropsychology at neurological hospital of Moscow University. The young researchers have created a program compensating motor subcortical disturbances in Parkinson's disease through a cortical (visual) mediation of movements (Luria, 1948/1963; Vygotsky, 1978). The program consisted of two main stages:

1. Training stage, when the patient was trained to use cues with a gradual decrease in external cueing.

2. Interiorization stage, when the external cues are gradually replaced by their internal images, that become internal means for the patient to control own motor behavior.

We used this idea of mediation as a means of transformation of functional systems in an integrated program for rehabilitation of different mental functions: memory, attention, writing, vocabulary, counting, problem solving, space orientation, movements and emotional sphere both in parkinsonian patients and in learning disable children (Glozman, 1999b, 2013).

The rehabilitation effect depends from teaching modalities: participative-guided and peer-collaborative approaches are more efficient than classical-expositive methods. Important are the optimal individualized choice of mediating means and the interhemispheric interaction: interfunctional mediation (semantic/visual) is in most subjects more efficient, than intrafunctional with some limitation for patients with specific features of interhemispheric interaction.

In general, the rehabilitation process for all subjects must be oriented to the personal goals of the patient and his/her family.

## Integration of Qualitative and Quantitative Approaches

As already stated, Luria's approach presupposes a qualitative analysis of the symptom under study, based upon an understanding of the factors, underlying complex psychological activities. The quantitative evaluation of disturbances is of primary value for determining the dynamics of change in cognitive functioning during neuropsychological follow-up, and for measuring the outcome of rehabilitative or remedial procedures.

We proposed a generalized system of rating of Luria's assessment method *a double system of patient's performances evaluation:* the first step is to make a list of possible defects in each task fulfillment (qualitative evaluation). The examiner puts plus or minus for each item in the list for every one patient. It results in:

1. Neuropsychological pattern of cognitive disorders for the examined patient.
2. Typical neuropsychological pattern of cognitive disorders for the studied group of patients.
3. Dynamics of the patterns after treatment: a disappearance of some symptoms (positive dynamics) or an appearance of the new ones (negative dynamics).

The second step consists in quantitative evaluation of the degree of each symptom and the severity of disturbances (a quantitative expression of the pattern of disturbances and of the level of the patient's performance) through a six points scoring system. This method takes account of normative reference, of the qualification of the symptoms (primary or secondary defects), conditions of mistake's corrections and possibilities to organize the test successful fulfillment with or without external assistance (Glozman, 1999a, 2012).

## Conclusions

Luria's approach or *Lurianism* [the term, proposed by J. Peña-Casanova (1989)] is based on systemic cultural-historical approach. Due to it, Luria has created a meta-theory of human mental functions.

Luria's neuropsychology is an interdisciplinary field that investigates interrelations among culture, mind and the brain. This assured the uniqueness of Lurian neuropsychology (Moskovich, Bougakov, DeFina, & Goldberg, 2002).

Luria's neuropsychology is a model of how to combine science and humanism, theory and practice, how to see the observed phenomena as a complex. Scientific observation is not just phenomenological description of separate facts.

> Its main goal is to view an event from as many perspectives as possible. The eye of science does not probe "a thing" or an event isolated from other things or events. Its real objective is to see and understand the way a thing or event relates to other things or events (Cole et al., 2006, p. 177).

To inherit all these features of Lurianism in their complexity, integration and inter-influence means to inherit in full the legacy of Alexander Luria.

Three main trends can be seen in the evolution of neuropsychology after Luria:

1. Extensive further expansion of research and practice, that is, embracing numerous new domains and nosological patient groups.
2. Integration of qualitative and quantitative approaches for analysis of neuropsychological assessment results.
3. A social, cultural and personality-based orientation in most neuropsychological studies all over the world.

It should be underlined, that these trends meet well *the main principles of a psychological study,* formulated by Luria in his first book, as far as in 1922 (Luria, 1922/2003)**:**

- To deal with the concrete personality, the living human being, as a biological, social and psychological unity.
- To study individual regularities, uniquely determined sequences, that is to combine a description of individual, unique processes with the study of lawful, regular processes.
- To study an individual human mind as a whole and the particular mental phenomena as functions, elements of this whole, developing in this concrete human personality, with the possibility of change through the transformation of social conditions.
- To study individual values of the examined psychological phenomena for the life of the actual personality.

All the previously mentioned shows, that Luria's creative and comprehensive approach stimulates the further evolution of neuropsychology in Russia and throughout the world.

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# Functional Systems and Brain Functional Units Beyond Luria, With Luria: Anatomical Aspects

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# Функциональные системы и функциональные блоки мозга после Лурия, с Лурия: анатомические аспекты

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This paper describes the anatomical aspects of a functional brain model that develops A. R. Luria's ideas. Five functional brain units are described on the basis of ontogenetic, anatomical, histological, functional, and clinical studies: preferential or primordial (unit I), limbic (unit II), cortical (unit III), basal ganglia (unit IV), and cerebellar (unit V). This review allows two large integrated and interrelated functional complexes to be distinguished: a primordial-limbic complex (units I and II) and a supralimbic one (units, III, IV and V). There is consensus that there exists a clear interplay among the cortex, the basal ganglia, and the cerebellum. Three main simplified parallel cortico-basal ganglia systems have been recognized: limbic, associative, and sensorimotor. Certain structures (e. g. neuromodulatory systems, hypothalamus, and paralimbic cortex) form functional links among units. Future studies are required to develop and improve the proposed model.

***Keywords:*** *systems biology; complex systems; cerebral cortex; thalamus; cerebellum; basal ganglia; learning systems.*

В данной статье развиваются идеи А. Р. Лурия, касающиеся анатомических аспектов функциональной модели мозга. На основании онтогенетических, анатомических, гистологических, функциональных и клинических исследований описаны пять функциональных блоков мозга: преимущественные или первичные (блок I), лимбические (блок II), корковые (блок III), базальные ганглии (блок IV) и мозжечок (блок V). Этот обзор позволяет выделить два крупных интегрированных и взаимосвязанных функциональных комплекса: примордиально-лимбический комплекс (блоки I, II) и супралимбический комплекс (блоки III, IV, V). Существует консенсус, который представляет собой четкое взаимодействие между корой головного мозга, базальными ганглиями и мозжечком. Различают три основные упрощенные параллельные системы кортико-базальных ганглиев: лимбическую, ассоциативную и сенсомоторную. Некоторые структуры (например, нейромодулирующие системы, гипоталамус и паралимбическая кора) образуют функциональные связи между блоками. Для разработки и улучшения предлагаемой модели необходимы дальнейшие исследования.

***Ключевые слова****: системная биология; сложные системы; кора головного мозга; таламус; мозжечок; базальный ганглий; системы обучения.*

## Introduction

As proposed by A. R. Luria, mental functions, as complex structures, are organized in systems of concertedly working zones, each of which performs its role and may be located in completely different, and often far distant, areas of the brain (Luria, 1973a). Luria also recognized the existence of grounds for distinguishing three main functional units of the brain whose participation is necessary for any type of mental activity (Luria, 1973a). These units were described as: (I) unit for *regulating tone and waking and mental states* (brain stem, diencephalon, and mesial regions of the cortex); (II) unit for *obtaining, processing and storing information coming from the outside world* (lateral postcentral regions of the neocortex on the convex surface of the hemispheres); and (III) a unit for *programming, regulating and verifying mental activity* (precentral anterior regions of the hemispheres) (Luria, 1973b).

In a recent paper (Peña-Casanova, 2018), Luria's model of three functional units of the brain was reviewed. In this process an ad hoc search of published medical literature on the subject was carried out. A total number of 15 guidelines was defined in order to develop a new model. The proposed model was characterized by the following elements: Luria's unit I was maintained, but expanded with new components; a limbic unit was differentiated; Luria's units II and III were unified in a single unit; and two new units were added: striatal (basal ganglia) systems (unit IV) and cerebellar ones (unit V).

It includes elements that are missing from Luria's model and avoids the corticocentric approach characteristic of classical neuropsychology. It was concluded that the new approach would allow a better analysis of the effects of brain pathology on cognition, neuropsychiatry, and behavior. Within the proposed framework, the concept of complex functional system was maintained and expanded.

## Objectives

This paper intends to go several steps further in the development of a five-block brain functional model. Specifically, it will deal with *anatomical* aspects not previously discussed. We will try to develop the idea that anatomical structures do not allow the clear establishment of separate functional systems. In that regard, functional units are abstractions within the global and integrated function of the brain (Luria, 1973a). It will also be shown that brain organization presents inter-related functional systems, with structures that act as functional hubs. Finally, this paper will try to generate an anatomical working sketch for future developments of the model.

## Methods

A specific PubMed search (from January 2018 to December 2019) was performed in the following fields: cortex, telencephalon, hippocampus, amygdala, thalamus, basal ganglia, cerebellum, connectome, and learning.

## Development

The first two sections of this review will be devoted to the ontogenetic and phylogenetic basis of the brain systems and the theory of functional systems, respectively. Two more sections will be concerned with the proposed functional units. In these sections the main anatomical structures that compose each unit will be commented on (*Tables 1 to 5*).

### Ontogenesis, Phylogenesis, and the Functional Organization of the Brain

On the fifth day of gestation, the rostral extremity of the neural tube resembles a median holosphere with two primordia or *anlagen* [from the German word] distributed symmetrically — right and left sides. These primordia represent the subcortical structures of the brain, and the cerebellar hemispheres will be one of the results of their development (Yakovlev, 1948; Lecours & Simard, 1998). In this part of the brain, the right and the left parts grow equally, with no laterality effect on the body.

Brain development shows, in the five vesicle phase (5 weeks of gestation), three main divisions: (1) rombencephalon (myelencephalon [medulla oblongata], and metence-

phalon [pons, and cerebellum]); (2) mesencephalon (midbrain); and (3) prosencephalon. The prosencephalon (forebrain) is further divided into (4) the diencephalon (hypothalamus, thalamus and epithalamus), and (5) the telencephalon (cerebral hemispheres: cortex, subcortical white matter, basal ganglia and basal forebrain nuclei) (Yakovlev, 1948; Lautin, 2002; Blumenfeld, 2010). From embryogenesis studies, P. I. Yakovlev (1948) proposed a tripartite neuroanatomic and behavioral architecture of the cortex (pallium): entopallium, mesopallium, and ectopallium, arranged in concentric rings. The entopallium is intimately bound to the rostral end of the brainstem, the hypothalamus. Each of these pallial layers constitutes a different telencephalic division, respectively: (1) telencephalon *impar*, (2) telencephalon *semipar*, and (3) telencephalon *totopar*. The boundary between telencephalon semipar and totopar is gradual (see Lautin (2002) for comparative and historical details). Yakovlev related each of the *three brains* to a different type of motility:

- *The telencephalon impar* (median zone, rhinic) includes the septum, the para-olfactory areas (subcallosal areas of Broca), the olfactory bulbs (paleocortex), and the hippocampi (archicortex). The rhinic brain is devoted to the *endokinesis* or the *cell-bound movement*, related to visceral motility (e. g. peristalsis).
- *The telencephalon semipar* (limbic zone, paramedian), includes the cingular gyrus, the isthmus of the cingulate, the parahippocampal gyrus, the limen isulae, and the insula. The semipar brain, according to Lautin (2002), is considered isomorphic with Brocas's lobe (gyrus fornicatus, olfactory lobe). The mode of projection of telencephalon semipar is ambilateral, and is related to *ereismokinesis* or *body-bound movement*, dedicated to the expression of emotions (e. g. pain, mimicry, swearing).
- *The telencephalon totopar* (supralimbic zone). The ontogenetic evaginations of this telencephalon are the primordia (anlagen) of the frontal, parietal, temporal, and occipital lobes (Yakovlev, 1948). The telencephalon totopar has a contralateral mode of projection and it is related to *telokinesis* or *object bound* voluntary motility (e. g. tool use).

Yakovlev's theory is clearly vertical (parallel rings) and based on cyto- and myeloarchitectonics in relation to assumed functions. Yakovlev's distinctions allows the recognition of three major brain zones: median, limbic, and supralimbic (neocortical). In fact, Luria distinguished a first functional brain unit (I) in which Yakovlev's median and limbic zones were considered as a whole. This whole has a clear physiological sense, especially in the field of emotions, and in cortical activation and modulation.

In fact, Luria (1973a) divided Yakovlev's supralimbic structures anatomically and functionally into two units: posterior (II), and anterior (III), a differentiation based on anatomy (Rolando's fissure as reference). Although it is undoubedly of clinical interest, it has currently no consistent physiological basis. The division of the cerebral cortex into cytoarchitectonic global zones (Mesulam, 2000), and its subcortical connections, makes much more sense. In addition, functional studies show a clear differentiation of a series of global networks beyond the anterior-posterior dichotomy (Yeo et al., 2011) [see below]. On the other hand, due to the prevailing ideas during the last century (Parvizi, 2009), the specific role of the basal ganglia and the cerebellum was not considered in Luria's model.

**Exaptation**. Phylogenesis provides a very interesting background in order to understand brain function. Recent studies have demonstrated that basal ganglia circuitry is present in the phylogenetically oldest vertebrates. This kind of circuitry has been conserved, most likely as a mechanism for action selection used by all vertebrates (Stephenson-Jones, Samuelsson, Ericsson, Robertson, & Grillner, 2011; Grillner & Robertson, 2016). Exaptation represents a process by which an ancestral core unit has been co-opted for multiple functions (Gould & Vrba, 1982). In this regard, emotional/affective and cognitive regulations are considered as extensions of the motor control system. Consequently, for the basal ganglia, motor functioning, emotion, and cognition constitute similar and parallel processes (Koziol & Budding, 2009). The evolution of the brain also shows a parallel growth of the cortex (mainly frontal and inferior parietal lobes), the caudate nucleus, and the lateral hemispheres and dentate nucleus of the cerebellum (Parvizi, 2009). This development (by exaptation) generates two parallel vertically organized cortical-subcortical-cortical series of loops: the basal ganglia system (cortex, basal ganglia, thalamus, and back to the cortex), and the cerebellar system (cortex-pons, cerebellum, thalamus, and back to cortex). This fact explains the functional continuity between the limbic (ventral striatum) and supralimbic (dorsal striatum) systems (Doya, 2000a; Koziol & Budding, 2009; Blumenfeld, 2010).

### Functional Systems

The theory of functional systems (Anokhin, 1935) represents a view opposed to reflexes. Reflexes are based on a linear processing of information (stimulus-response), from receptors to effectors. Unlike reflexes, the basic principle of functional systems is the physiological self-organizing non-linear relationship between distributed local systems to establish a holistic system or "integrated unit" (Luria, 1973a). In contrast to reflexes, the goals of functional systems are not specific actions by themselves but the adaptive results of these actions: "The presence of a constant (invariant) task, performed by variable (variant) mechanisms, bringing the process to a constant (invariant) result" was considered one of the basic features distinguishing functional systems (Luria, 1973b, p. 28).

In this field, it is crucial to recognize two types of functional systems, and their differentiated contribution to the homeostasis of the individual (Luria, 1973a):

- *Functional systems type I (Elementary).* These kinds of functional systems provide homeostasis thanks to internal resources of the body, inside its boundaries. Homeostasis is a state of internal physical and chemical equilibrium that maintains life (Bernard, 1866; Cannon, 1932). Such an equilibrium includes a series of variables, including body temperature, heart rate, ion concentration, fluid balance, extracellular fluid pH, and blood glucose level. Each of these variables is regulated by one or more homeostatic mechanisms. All these functions depend on primitive evolutionary systems located primarily in the brainstem and in Yakovlev´s telencephalic medial, or rhinic zone, intimately bound to the hypothalamus. Even in a situation of sleep, biologically interoceptive relevant information (cold, bladder distention) can promote awakening (Seeley & Strum, 2007). Representations of the internal state allow critical signals to be activated and motivated in order to solve basic ho-

meostatic needs. The cries of the newborn represent homeostatic needs, and also integrated limbic unpleasantness. Crying (alarm) involves the activation of the maternal environment (mother) to meet the homeostatic needs of the newborn.

- *Functional systems type II (Complex).* These second kind of functional systems support homeostasis thanks to the execution of different types of behavior interacting with the outside world (Anokhin, 1935; Luria, 1973a). The second type "are organized into complex behavioral systems, as a result of whose action the appropriate needs are satisfied and the necessary balance of the 'internal economy of the organism' is restored" (Luria, 1973b, p. 53). In humans, homeostatic interoceptive afferent information reaches the dorsal posterior insula, via the posterior ventromedial thalamus. This information is forwarded to the anterior insula, of the nondominant hemisphere, providing the biological substrate for conscious, evaluative interoception. Thanks to insular connections to the amygdala, the anterior cingulate cortex and frontal cortex, interoceptive signals may generate contextually optimized behaviors (see Seeley and Sturm, 2007). Beyond biological needs, complex functional systems type II, are the foundation of complex forms of socio-cultural behavior (Vygotsky, 1960, 1965 [on extra-cortical organization]; Luria, 1974). At this point the importance of the socio-historical approach appears (Leontiev, 1959 [on "new functional organs"]; Luria, 1974; Ardila, 2018). Luria also recognized that the localization of higher mental processes in the human cortex is never static or constant. He stated that localization "moves about essentially during development of the child and at subsequent stages of training" (Luria, 1973b, p. 31). The important contribution of both Luria and Vygotsky to developmental neuropsychology has been recognized (Akhutina & Pylaeva, 2011).

### Unit 1: Preferential or Primordial Systems

**Major neural structures that compose unit I.** This unit is composed of the medial and most primitive structures of the brain: the brainstem (medulla, pons, and mesencephalon) and diencephalon (see *Table 1*). Certain components of this unit (e. g. reticular and neuromodulatory systems) expand into the entire brain (Blumenfeld, 2010).

*Table 1*

**Unit I (preferential or primordial systems): Main structures**

| |
|---|
| **A. Brainstem (medulla, pons, and mesencephalon [midbrain])** |
| **1. Cranial nerve nuclei and additional related structures (nuclei and pathways)** |
| • Associated with eye movements: pretectal area; superior colliculus, MLF (and its rostral interstitial nucleus); convergence center; paramedian pontine RF; accessory hypoglossal nucleus |
| • Associated with hearing: superior olivary nuclear complex; trapezoid body; lateral lemniscus; inferior colliculus |
| • Associated with cranial nerve functions: RF, central tegmental tract |

*Table 1 (continued)*

**2. Long tracts**

- Motor pathways: corticospinal, rubrospinal, vestibulospinal, reticulospinal, tectospinal
- Somatosensory pathways: medial lemniscal pathway (fine touch, vibration, joint position); anterolateral pathways (pain, temperature, crude touch)

**3. Cerebellar circuitry**

- Cerebellar peduncles
- Pontine nuclei, red nucleus (parvocellular), central tegmental tract, inferior olivary nucleus

**4. Reticular formation and related structures**

- Systems with diffuse (widespread) projections
  - — Reticular formation (locations and *targets [T]*)
    - Rostral. Midbrain and upper pons (pontomesencephalic). *T: thalamic intralaminar nuclei, hypothalamus, basal forebrain* (alertness, conscious state)
  - — Thalamic intralaminar nuclei. *T: cortex, striatum* (alertness, conscious state)
  - — Midline thalamic nuclei. *T: cortex* (alertness, conscious state)
    - Caudal. Pons and medulla. *T: Cranial nerve nuclei and spinal cord links* (motor, reflex and autonomic functions)
  - — Specific neuromodulatory systems (locations and *targets [T]*)
    - **Norepinephrine**. Pons: nucleus ceruleus and lateral tegmental area. *T: global CNS* (alertness, mood elevation)
    - **Dopamine.** (1) SNc. *T: (mesostriatal pathway): neostriatum* (motor function): (2) VTA. *T: (mesolimbic pathway): limbic cortex, nucleus accumbens, amygdala, cingulate gyrus;* (3) VTA and scattered cells near the SN. *T: (nesocortical pathway): prefrontal cortex* (frontal function, working memory, attention)
    - **Serotonin.** Midbrain and pons: raphe nuclei. *T: global CNS* (mood elevation)
    - **Acetylcholine**
      - — Basal forebrain: NBM, Medial septal nucleus, BNDB. *T: cortex* (alertness, memory)
      - — Pontomesencephalic zone: pedunculopontine nucleus and laterodorsal tegmental nucleus. *T: thalamus, cerebellum, pons, medulla* (alertness, memory)
    - **Histamine.** Midbrain: reticular formation; hypothalamus: tuberomammillary nucleus. *T: global brain* (alertness)
- Nuclei involved in sleep regulation
- Pain modulatory systems (periaqueductal gray; rostral ventral medulla)
- Brainstem motor control systems
  - — Posture and locomotion (reticular formation; vestibular nuclei; superior colliculi; red nucleus [magnocellular]; SN; pedunculopontine tegmental nucleus
  - — Respiration, cough, hiccup, sneeze, shiver, swallow, nausea, and vomiting (chemotactic activation zone)
  - — Autonomic control (including blood pressure and heart rate; sphincter control, including pontine micturition center)

*Table 1 (continued)*

**B. Diencephalon**
- Thalamus; epithalamus (habenula and pineal body); hypothalamus

**C. Autonomic systems (central)**
- Sympathetic division; parasympathetic division; enteric division

*Note*. MLF = medial longitudinal fasciculus; RF = reticular formation; SNc = substantia nigra pars compacta; VTA = ventral tegmental area; SN = substantia nigra; NBM = nucleus basalis of Meynert; BNDB = bed nucleus of the stria terminalis.

The brainstem is, evolutionarily-speaking, the oldest part of the human brain. It is the part of the brain that most closely resembles those of fish and reptiles (Blumenfeld, 2010). Several structures of the brainstem are significantly involved in basic bodily functions necessary for biological survival, and in behavior. The diencephalon, located between the midbrain and the telencephalon, also plays a crucial role in autonomic processing. As previously commented, the telencephalon impar (median zone, rhinic) includes the septum, the para-olfactory areas (subcallosal areas of Broca), the olfactory bulbs (paleocortex), and the hippocampi (archicortex). These structures will be studied within the context of unit II. For an anatomical and clinical approach see Blumenfeld (2010) and Clark, Boutros, and Mendez (2018).

Unit I systems are termed preferential (or primordial) because they have a functional priority due to their participation in life-supporting processes (Peña-Casanova, 2018). As discussed in later sections, certain structures (e. g. hypothalamus) are shared with unit II.

Phylogenetically, the limbic system (unit II, see below) is highly interconnected with homeostatic regulation systems (Luria, 1973a; Mesulam, 2000). The hypothalamus (e. g. paraventricular nucleus [as overlapping structure]) plays a role of physiological interconnection with the amygdala, the hippocampus, and the autonomic systems (Hariri, 2015). This is why it is recognized, as previously stated, as an integrated primordial-limbic complex (units I and II of the proposed model), in concurrence with Luria (a single unit, I).

Traditionally, it is assumed that neuromodulators are involved in the control of general arousal. The specific function of primitive dopaminergic systems (mesostriatal [nigrostriatal], mesolimbic, and mesocortical) is crucial for motor, emotional, and cognitive functions (for a clinical view see Blumenfeld, 2010). Currently, it is possible to build a more specific and comprehensive view concerning the physiological functions of neuromodulators. In fact, a computational theory proposes that neuromodulators regulate distributed learning systems in the brain (Doya, 2000b, 2002).

### Unit II: Limbic System

**Major neural structures that compose unit II.** This unit is composed of limbic areas, paralimbic cortex (mesocortex), and related structures (see *Table 2*).

*Table 2*

**Unit II (limbic system). Main structures and principal pathways**

**1. Limbic components**

- Corticoid structures
  - — Septal region, diagonal band of Broca, substantia innominata (nucleus basalis of Meynert [NBM], and bed nucleus of the stria terminalis [BNST]), and amygdaloid complex (amygdala)
    - *Stria terminalis = amygdala-hypothalamus and septal nuclei connection*
    - *Ventral amygdalofugal pathway = amygdala — hypothalamus, nucleus basalis, ventral striatum, and brainstem nuclei connections*
    - *Medial forebrain bundle = Amygdala (and other forebrain structures and brainstem nuclei) reciprocal connections*
- Allocortex
  - — Paleocortex: piriform cortex (primary olfactory cortex)
  - — Archicortex: Hippocampus. Hippocampal formation = dentate gyrus, hippocampus, subiculum, presubiculum, parasubiculum, entorhinal cortex
    - *Papez circuit = hippocampus — mammillary body (via the fornix) — anterior thalamic nuclei (via the mammillothalamic tract) — cingulate gyrus, presubiculum, entorhinal cortex, hippocampus (via the performant and the alvear pathways)*

**2. Paralimbic zone (mesocortex)**

- Orbitofrontal cortex
- Insula
- Temporal pole
- Parahippocampal cortices
  - — Presubiculum, parasubiculum, entorhinal, prorhinal, and perirhinal (transentorhinal) area
- Cingulate complex
  - — Retrosplenial, ventral cingulate, and paraolfactory areas

**3. Limbic basal ganglia and other structures**

- Limbic basal ganglia
  - — Limbic striatum: nucleus accumbens septi (AcS), and olfactory tubercle (OT),
  - — Limbic pallidum: NBM, and BNST
- Ventral tegmental area (VTA) of Tsai (Midbrain)
  - — *Mesolimbic pathway = VTA-limbic connection (mainly amygdala, cingulate gyrus, nucleus accumbens, temporal cortex)*
- Habenula (Diencephalon. Epithalamic structure)
  - — *Stria* medullaris = septo-habenular connection
  - — Habenulointerpeduncular tract (f. retroreflexus) = interpeduncular nuclei (IP) (midbrain) connection *(The IP projects to raphe nuclei and to dopaminergic nuclei)*

*Table 2 (continued)*

**4. Limbic and paralimbic thalamic nuclei**

- Anterior dorsal, anterior ventral, anterior medial, laterodorsal, mediodorsal, medial pulvinar, and other midline nuclei

**5. Hypothalamus**

*Note*. The NBN belongs to the limbic zone of the cortex and is also an extension of the reticular core of the BS. After Mesulam (2000).

Although Luria (1973a) discussed the functional role of the paleocortical and archicortical structures, and commented on the significance of Klüver and Bucy, and Bechterev-Korsakov, syndromes, he did not differentiate a limbic unit.

Beyond Yakovlev's telencephalic differentiations, the unit discussed here is based on current structural, physiological, and neurobehavioral data that characterize the limbic system. It is worth commenting that this unit has been previously proposed by other authors (e. g. Jubert, 1983; Téllez & Sánchez, 2016).

As already mentioned, the hypothalamus constitutes a relevant structure in the integrated primordial-limbic functional complex. Similarly, the limbic striatum and the limbic pallidum are part of the striatal systems (unit IV) of the integrated supralimbic functional complex.

Limbic structures have three main functions: olfaction (piriform cortex), context / episodic memory (hippocampus), and emotions, feelings and drives (amygdala) (Mesulam, 2000; Blumenfeld, 2010; Clark et al., 2018). The role of the main limbic structures (corticoid and allocortex) will be briefly discussed in the following paragraphs. For more information see Clark et al. (2018).

**Limbic areas (corticoid and allocortex).** Corticoid areas (see above) show cytoarchitectonic features that have cortical and nuclear characteristics (Mesulam, 2000). They also present massive bilateral connections with the hypothalamus. The main characteristics of these structures are summarized below:

- *Main basal forebrain related structures.* Septal area, diagonal band of Broca, and substantia innominata (NBM and BNST) constitute part of the basal forebrain. These structures form a collection of cholinergic, GABAergic, and glutamatergic projection neurons and local GABAergic interneurons. They are made up of three main complexes. Two complexes projecting to the hippocampus, to the olfactory bulb and the piriform cortex, and one complex (NBM-substantia innominata) projecting uniformly to the neocortex.
- *Amygdala and related structures.* The amygdala receives information from the sensory cortices (high-resolution information), and from the thalamus (low-resolution information). The amygdala acts as an emotional hub and contributes to reward/motivation processing. It is considered as an *evolved system for relevance detection* (Sander, Grafman, & Zalla, 2003). It sends inputs to the hypothalamus (hypothalamic-pituitary-adrenal axis activation), brainstem (sympathetic arousal),

substantia innominata (alertness), insula (interoception, pain), hippocampal formation (contextual memory), and the prefrontal cortex (PFC) — attention, cognition (Whalen & Phelps, 2009). The PFC regulates the function of the amygdala (inhibition) (Hariri, 2015). Physiologically, emotions cannot be separated from the autonomic systems.

- *Olfactory (piriform) primary cortex and related structures.* The piriform cortex receives information from the olfactory bulb, and is bilaterally connected with the hypothalamus. It is directly connected with practically all the mesocortical and limbic areas. The olfactory sense plays a key role in territorial, sexual, and feeding behaviors (Mesulam, 2000).
- *Hippocampal formation.* The hippocampal formation (HF) receives reciprocal information from sensory association areas, and from the dorsolateral PFC (for a comprehensive review see Andersen, Morris, Amaral, Bliss, and O'Keefe, 2007). The dorsolateral PFC is modulated by dopaminergic mesencephalic afferents. The HF is related to the information about the context (where? when? what? who?) of lived experiences. Thanks to its particular functional organization, the HF combines all contextual information. Context is defined as "the set of circumstances around an event" (Maren, Phan, & Liberzon, 2013, p. 418). Contexts (spatial, temporal, interoceptive, cognitive, social, and cultural) are crucial for abstraction of situationally informed meanings of the world, and adaptation. The connections of the hippocampus with the ventral striatum (VS) contribute to the learning of the contexts in which a specific motivation is satisfied, through a specific behavior (Hariri, 2015). When the context reappears, the HF contributes to the opening of the ventral striatum. This gate will activate, on the one hand the dorsal striatum/pallidum (towards the thalamus and the motor cortex), and on the other hand, the ventral pallidum. In addition, the VS will activate the hypothalamic function (Hariri, 2015). Recent studies suggest that the hippocampus, beyond memory, contributes in the domains of decision-making, language, social cognition, and a variety of other capacities that are critical for flexible cognition (Hannula & Duff, 2017).

**Mesocortex (paralimbic cortex)**. This type of cortex is intercalated between the allocortex and isocortex (Yakovlev, 1948; Mesulam, 2000; Pandya, Seltzer, Petrides, & Cipolloni, 2015). Phylogenetic research in mammals has demonstrated two waves of transition, or trends, from the allocortex to isocortex: the olfactocentric and hippocampocentric trends (Sanides, 1969; Mesulam, 2000). These two trends generate the paralimbic ring. The olfactocentric (piriform cortex, olfactory paleocortex) trend provides the orbitofrontal, insular, anterior parahippocampal, and temporopolar mesocortex. The olfactocentric trend is closely associated with the amygdala. The hippocampus and the induseum griseum (archicortex) constitute the primordia for the entorhinal cortex, the cingulate gyrus, and the posterior parahippocampal mesocortex (Pandya et al., 2015). For a comprehensive review on the cingulate neurobiology and disease see Vogt (2009).

### Unit III: Cortical Systems

**Major neural structures that compose unit III.** This unit includes all the cortices (limbic, paralimbic, and supralimbic) (see *Table 3*), related thalamic systems, and cortico-cortical pathways (intra- and interhemispheric association). In fact, unit III consists of the entire cortex and their cortico-cortical connectome (Catani & Thiebaut de Schotten, 2012). The cortical unit, together with the basal ganglia and the cerebellar systems, constitute a large *integrated limbic-supralimbic complex.* Due to the exaptation of the primitive circuits of the basal ganglia, the ventral striatum performs a functional interplay with the dorsal striatum (Hariri, 2015; Yin H. H. & Knowlton, 2006).

*Table 3*

**Unit III (cortical systems): Main structures. Cortical types (supralimbic and paralimbic) and corresponding Brodmann areas (BA). After Mesulam (2000), and Blumenfeld (2010)**

**1. Paralimbic mesocortex**

- Orbitofrontal cortex: [BA11–12 (posterior parts), BA13]
- Insula [BA14–16]
- Temporal pole [BA38]
- Parahippocampal cortices [BA27–28, 35]
- Cingulate complex [BA23–26, 29–33]

**2. Homotypical isocortex (classical secondary areas)**

- Modality specific (unimodal) association areas
  - — Motor: premotor cortex [anterolateral BA6]; FEF [BA8–6], SMA (medial face of the hemisphere) [Mainly BA6], supplementary eye fields [BA6], Posterior part of Broca's area [BA44]
  - — Visual: peristriate [BA18–19], parts of the fusiform, inferior temporal and middle temporal gyri [BA37, 20, 21]
  - — Auditory: mid- to anterior superior temporal gyrus [BA22]; middle temporal gyrus [BA21]
  - — Somatosensory: anterior rim of the superior parietal lobule [BA5]; rest of the superior parietal lobule [BA7]; parts of the posterior insula; anterior segment of the supramarginal gyrus [BA40]; S2 area in the parietal operculum (next to the dorsal insula)
- High-order (heteromodal) association areas (classical tertiary areas)
  - — Prefrontal association cortex [BA9, 10, 11, 12, 45, 46, 47]
  - — Parieto-temporal association cortex: posterior parietal [BA7]; supramarginalis [BA40]; angularis; BA 39]

**3. Idiotypic cortex (primary sensory-motor areas)**

- Primary motor (M1) [BA4]
- Primary somatosensory (S1) [BA3a, 3b, 1, 2]
- Primary visual (striate, calcarine, or V1) [BA17]
- Primary auditory koniocortex (A1) [BA41–42]

*Table 3 (continued)*

**Addenda**

**4. Claustrum** (telencephalic pallial subcortical structure)

- Dorsal or insular
- Ventral

*Note*. FEF = frontal eye fields; SMA = supplementary motor area. **Broca's region** includes premotor cortex [BA44] (*opercularis*), and adjacent heteromodal cortex: *triangularis* [BA45], *orbitalis* [BA47], and frontal dorsolateral [BA46, 9]. **Wernicke's region** includes the following areas: posterior BA22, and parts of the adjacent heteromodal cortex [BA39–40], and possibly parts of the middle posterior gyrus.

A cytoarchitectonic study of the cerebral cortex shows that the cerebral hemispheres can be subdivided in numerous areas based on variations in neuronal architecture (cell types, number of layers, and canonical microcircuits). Five large functional cortical subtypes have been recognized: limbic, paralimbic, heteromodal association, unimodal association, and primary sensory-motor (Mesulam, 2000) (see *Table 3*). Such differentiation is crucial for the analysis of cerebral focal syndromes and their pathophysiology.

To be more exhaustive, a special subcortical structure has been included in this unit: the claustrum. The claustrum is a telencephalic, pallial structure that consists of the main divisions: dorsal or insular claustrum placed medial to the insular cortices, and the ventral claustrum placed medial to the piriform cortex (Druga, 2014). The claustrum integrates cortico-cortical links and has been recognized as a central node for consciousness (Yin B., Terhune, Symthies, & Meck, 2016). For more information see Mathur (2014), Binks, Watson, and Puelles (2019), Torgerson and Van Horn (2014).

Unit III is related to semantic memory, episodic (contextual) memory, unsupervised learning (Doya, 2000a), and the associative global processing of circulating brain information. The cortex allows the establishment of flexible FS, and the final behavioral output (McFarland & Sibly, 1975) according to cortical computations and extra-cortical inputs.

Unit III highlights local cortical processing in the global functional context of the brain. By highlighting this differentiated unit, it is possible to properly analyze cortical and cortico-subcortical focal syndromes (e. g. aphasia, apraxia, and agnosia). Restricted cortical lesions will give rise to symptoms depending on the type and modality of local processing (Luria, 1973a). It should also be noted that the analysis of cerebral local syndromes should be performed with a double (hodotopic) approach: topological (location) and hodological (affected connections). See Catani and Thiebaut de Schotten (2012).

The **thalamus** integrates multimodal information across diverse functional networks (Hwang, Bertolero, Liu, & D'Esposito, 2017; Dehghani & Wimmer, 2019), and acts as a gateway to mental representations [the "cognitive thalamus"] (Wolff & Vann, 2019). Pulvino-cortical feedforward and feedback pathways participate in cognitive computations (Jaramillo, Mejias, & Wang, 2019), and the nucleus reuniens sits at the nexus of a hippocampus and medial prefrontal cortex circuit enabling memory and behavior

(Dolleman-van der Weel et al., 2019). As a paradigm of functional cortical interactions, the precuneus, the lateral temporal cortex, the medial PFC, and the posterior parietal cortices participate in multiple paralimbic networks that together comprise subsystems of the default mode network (Yeo et al., 2011).

The role of connection pathways (connectomics) is essential to understand cortical and brain function (Kennedy, Van Essen, & Christen, 2016; Sporns, 2016). The adult human structural connectome shows a hierarchical complexity (Smith et al., 2019), with centralized and distributed cognitive task processing (Amico, Arenas, & Goñi, 2019). Recent studies have reported a shared vulnerability for connectome alterations across psychiatric and neurological brain disorders (Lange et al., 2019; van den Heuvel & Sporns, 2019; Baker et al., 2019).

**Cortical learning: unsupervised learning.** This type of learning implies a concise representation of sensory state, context, and action. In fact, it entails finding the appropriate modular architecture of a given task (Doya, 2000a). It is guided by the statistical properties of the input signal itself. This process may be regulated by ascending neuromodulatory inputs (Doya, 2000b).

### Unit IV: Basal Ganglia Systems

**Major neural structures that compose unit IV.** This unit is composed of three main, highly simplified, parallel, cortico-basal ganglia systems: limbic, associative, and sensorimotor (Yin H. H. & Knowlton, 2006), see *Table 4, Figure 1*. These main systems are further divided into a myriad of circuits. The basal ganglia comprise a group of subcortical structures distributed within the telencephalon, diencephalon, and mesencephalon. It also includes the pedunculopontine (pedunculotegmental) nucleus, a midbrain-pontine nucleus, and parts of the basal forebrain.

Cortico-striatal systems form an integrated cortical-subcortical system of motor and emotion control, behavioral selection (decision-making), reinforcement (reward) learning, language, praxis, gnosis, and procedural memory (Cox & Witten, 2019; Simonyan, 2019). The canonical basal ganglia (BG) circuits (cortex — striatum — pallidum — thalamus — cortex) perform a process of selective disinhibition of the thalamus (Doya, 2002; Koziol & Budding, 2009; Blumenfeld, 2010; Henke, 2010). Midbrain dopaminergic systems modulate basal ganglia circuits. Recent advances have shown a role of basal ganglia in psychiatric disorders (Macpherson & Hikida, 2019).

*Table 4*

**Unit IV (corticostriatal systems): Main structures**

| |
|---|
| **1. Limbic network** |
| • Cortex: Prefrontal cortex (orbital and ventral) |
| • Basal ganglia |
| — Limbic striatum (nucleus accumbens septi [ACs], olfactory tubercle [OT]) |
| — Ventral pallidum (nucleus basalis of Meynert [NBM], bed nucleus of the stria terminals [BNST]) |

*Table 4 (continued)*

- Thalamus: mediodorsal

**2. Associative (cognitive) network**

- Cortex: Prefrontal and parietal association cortices (fronto-parietal network)
- Basal ganglia
  - — Associative striatum (caudate / dorsomedial striatum)
  - — Associative pallidum
- Thalamus: mediodorsal / ventral

**3. Sensorimotor network**

- Cortex: Sensorimotor cortex
- Basal ganglia
  - — Sensorimotor striatum (putamen / dorsolateral striatum)
  - — Motor pallidum
- Thalamus: ventral

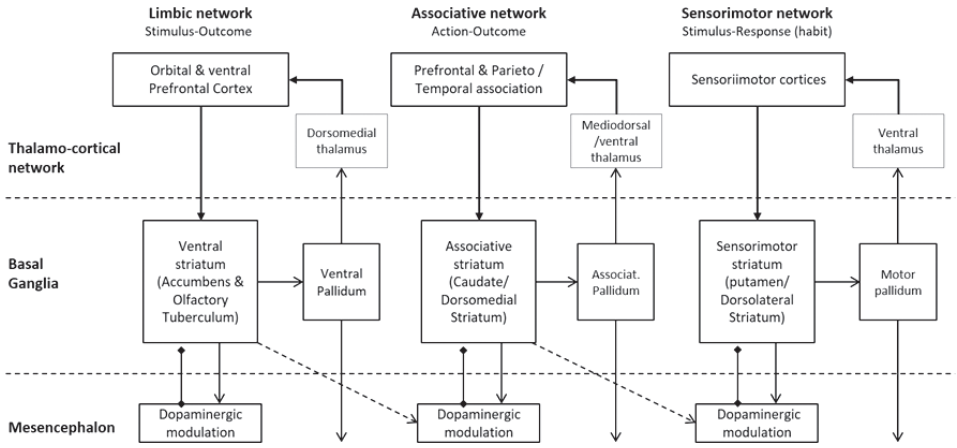


*Figure 1.* Unit IV. Basal ganglia systems. Three main networks: limbic, associative and sensorimotor. After Yin H. H. and Knowlton (2006)

The model of the basal ganglia system based on direct, indirect, and hyperdirect pathways (Koziol & Budding, 2009) has been challenged in the light of new tract tracing information. Recent studies have identified a direct connection between the cortex and the external and internal segment of globus pallidus (Quartarone et al., 2020).

The **limbic network** is associated with situations of stimulus-outcome (S-O), as in the case of emotions or conditioned learning (the stimulus generates the outcome). Motivation plays a major role in organizing behavioral decision and actions. Although the ventral striatum is considered a motivation-action gate (Hariri, 2015), the basal ganglia integrate motivation and action across their circuits. The striosomes (one of two com-

plementary compartments within the striatum [known as the matrix]) could contribute strongly to this merger (Courtemanche & Cammalleri, 2019).

The **associative network** is associated with novelty and executive actions. Novelty implies action-outcome (A-O) contingencies (Yin H. H. & Knowlton, 2006). Successful problem solving requires determining a synthesis of environmental information (afferent synthesis) and searching for the individual operations, which will be used to obtain the necessary results (outcome) (Koziol & Budding, 2009).

The **sensorimotor network** is associated with situations of stimulus-response (S-R) and habit formation (Yin H. H. & Knowlton, 2006). The stimulus (internal or external) triggers the appropriate response (Koziol & Budding, 2009). A shift from the associative to the sensorimotor cortico-basal ganglia network has been observed during the process of learning (Yin H. H. & Knowlton, 2006; Koziol & Budding, 2009).

**Basal ganglia learning: Reinforcement learning.** This type of learning is based on the "evaluation of the current situation by prediction of reward" (Doya, 2000a, p. 736). It implies the "selection of appropriate action by the evaluation of candidate actions" (Doya, 2000a, p. 736). Reinforcement learning is guided by the reward signal encoded in the dopaminergic input from the substantia nigra and the ventral tegmental area (Yin H. H. & Knowlton, 2006).

### Unit V: Cerebellar Systems

**Major neural structures that compose unit V.** This unit is composed of the cerebellar systems subdivided on the basis of their anatomical connectivity (see *Table 5*).

In recent decades, a series of studies have demonstrated and characterized the cerebellar functions beyond motor and vestibular control, including cognitive, autonomic, emotional, and social domains (Schmahmann, 2019; Schmahmann, Guell, Stoodley, & Halko, 2019; Leggio & Olivito, 2018). The cerebellum is of paramount importance for information computation thanks to the characteristic of its canonical circuitry, the enormous computational possibilities, and connectivity to other areas (Grimaldi & Manto, 2012).

*Table 5*

**Unit V (cerebellar systems): main structures. After Schmahmann et al. (2019), Schmahmann (2019)**

**1. Limbic / paralimbic network ("emotional cerebellum")**

- Limbic cerebellum (posterior vermis). Output via reticular nuclei, hypothalamus and limbic and paralimbic structures
  - — Cerebellar neuropsychiatric syndromes: posterior vermis lesions (interruption of cerebrocerebellar limbic loops, and related connections)

**2. Associative network ("cognitive cerebellum")**

- Cerebrocerebellum. Output via dentate nucleus to cerebral cortices
  - — Cognitive cerebellar syndromes: posterior lobe lesions, that affect lobules VI and VII, including Crus I, Crus, II, and lobule VIIB. (interruption of connections or impairment of cerebellar modulation of cerebral associative cortices).

*Table 5 (continued)*

**3. Motor and vestibular network ("motor and vestibular cerebellum")**

- Spinocerebellum (paleocerebellum): (1) medial part of cerebellar hemisphere (output *via interpositus nucleus* [globose + emboliform nuclei]). (2) Vermis (output via fastigial nucleus). Reticular formation connections
  - — Cerebellar motor syndrome: lesions that affect anterior lobe and parts of lobule VI (interruption of connections with cerebral and spinal cord motor systems)
- Vestibulocerebellum (archicerebellum): flocculonodular lobe and inferior vermis. Output mainly via vestibular nuclei and extraocular muscle nuclei
  - — Cerebellar vestibular syndrome: lesions that affect flocculonodular lobe (interruption of connections with cerebral and brainstem vestibular and eye movement systems)

**Divisions of the cerebellar systems.** Cerebellar circuits are segregated into functional areas (Brodal, 1992; Grimaldi & Manto, 2012). A classical subdivision of the cerebellum on the basis of functional differences corresponds to a subdivision on the basis of differences in the origin of the afferent fibers (Brodal, 1992).

Such division also corresponds with that based on cerebellar phylogenetic development (archicerebellum, paleocerebellum, and neocerebellun).

The *archicerebellum* consists of the small floculonodular lobe (the nodulus in the midline, connected laterally to the flocculus). This part of the cerebellum receives afferents primarily from the vestibular system (vestibulocerebellum). The *paleocerebellun* consists of the anterior and posterior parts of the vermis and adjoining parts of the intermediate zone. This part of the cerebellum receives afferents from the spinal cord (spinocerebellun). The *neocerebellum* consists of the lateral parts of the cerebellar hemispheres. The hemispheres receive the main input from the cerebral cortex, the cortico-ponto-cerebellar pathway (pontocerebellum). The simplified canonical cortico-cerebellar circuit is the following: cortex — pons — cerebellar cortex/dentate nucleus — red nucleus — thalamus — cortex (Ito, 2006).

The three main divisions of the cerebellum act reciprocally on the parts of the CNS from which they receive their afferents: the vestibulocerebellum sends fibers mainly to the vestibular nucleus, the spinocerebellum acts on the spinal cord, and the cerebrocerebellum influences the cerebral cortex and other structures (Brodal, 1992). In summary, the cerebellar systems are involved in sensoriomotor, limbic, and associative networks (Habas, Manto, & Cabaraux, 2019).

As previously stated, the activity of the cerebellar systems is performed in parallel with the basal ganglia (Milardi et al., 2019). Recent studies have demonstrated that the cerebellar anatomical connection pathways pass through specific subnuclei of the thalamus, the "cerebellar thalamus" (Habas et al., 2019). The central role of these connections should no longer be assimilated to a passive relay of information (Habas et al., 2019).

Studies of cases with cerebellar lesions permit the recognition of the functional topography and nature of three cerebellar syndromes: motor, vestibular, and cognitive affective (Schmahmann, 2019). Moreover, the cerebral cortical dorsal attention network

shows strong, selective connectivity with a set of cerebellar circuits, including lobule VIIb/VIIIA (Brissendent & Somers, 2019). These circuits exhibit functional properties characteristic of the cortical dorsal attention pathway: task-specific activation, working memory load-dependent responses, and the representation of visuospatial location. It has been suggested that parallel cortico-cerebellar pathways may play specific functional roles in a series of cognitive processes (Brissendent & Somers, 2019).

The limbic cerebellum acts upon the reticular nuclei (effects on the arousal system), the hypothalamus via the superior cerebellar peduncle (autonomic functions), and the cingulate and other limbic structures (emotions, and emotional experience) (Turner et al., 2007; Grimaldi & Manto, 2012). Beyond the traditional division of cerebro-cerebellar networks in sensoriomotor/cognitive modules, during emotional/social processing, the cerebellar activity shows a domain-specific mentalizing functionality that is strongly connected with the corresponding mentalizing network in the cerebrum. The phylogenetic recent lobules, such as lobules VI and VII (Crus II–II) within the posterolateral cerebellar hemisphere, have been implicated in social cognition (Leggio & Olivito, 2018).

**The universal cerebellar transform and orthometrics.** Unlike the cerebral cortex, the cerebellar cortex displays histological homogeneity (a single type of canonical circuit) (Shepherd, 2004). This fact implies that it performs a constant operation, which is termed *the universal cerebellar transform* (UCT) (Schmahmann, 2004, 2019; Schmahmann et al., 2019). This same operation will be applied to motor, vestibular, cognitive, and limbic activities (emotional and autonomic). Following the theory of the UCT, "the cerebellum maintains behavior around a homeostatic baseline, automatically, without conscious awareness, informed by implicit learning, and performed according to context" (Schmahmann, 2019, p. 62).

In a previous paper it was proposed that the cerebellum had an orthometric physiological function (Peña-Casanova, 2018). Orthometrics (or eumetrics), as opposed to dysmetria [dyschronometria or dysrhythmia (Blumenfeld, 2010)], involves the regulation and improvement of quality, efficiency, fluidity, intensity, softness, and, finally, the adaptability of motor, cognitive, behavioral, and emotional acts. In other words, orthometria implies the adequate graduation of the quality of the strength of an impulse to match the need. The same concept of motor dysmetria (or dyschronometria) observed in cases of cerebellar lesions is applicable to cognition and emotion (Schmahmann, 2004).

Cerebellar cognitive affective syndrome is the term applied to cognitive, emotional, and behavioral symptoms that appear in patients with lesions involving the cerebellum (Schmahmann, 2004; Koziol et al., 2014). In this context, the vermal region has been referred to as the "limbic cerebellum", and focal involvement of this area has been related to disturbances in emotional responsiveness, alterations in personality, as well as psychotic and behavioral disturbances (Schmahmann, 2004, 2019; Koziol et al., 2014; Schmahmann et al., 2019). Recent studies have reportedrelationships between cerebellar development, behaviour, and complex brain disorders (Sathyanesan et al., 2019).

**Cerebellar learning: supervised learning.** In fact, the cerebellum is specialized in a particular kind of learning. Its function is based on "internal models of the body and the environment" (Doya, 2000a, p. 738). Cerebellar function implies the "replication

of arbitrary input output mapping" (Doya, 2000a, p. 738) acquired in different locations of the brain. In this regard, the cerebellum has a function as a *predictor or anticipator* — informing the cerebral cortex about the predicted outcome (Koziol & Budding, 2009), and can be defined as a *supervised learning system.* The cerebellum is also related to classical conditioning (Henke, 2010).

**A note on the cerebellum in Luria's work.** Interestingly, an original case report from Luria's laboratory drew attention to cognitive deficits resulting from a cerebellar tumor (Kutsemilova, Luria, & Homskaja, 1964). This case report highlighted "pseudo-frontal" symptoms and cerebellar contributions to cognition (Budisavljevic & Rammani, 2012).

## Discussion

It must be recognized that the three functional unit model of Luria (1973a) was an early contribution to neuroscience. Brain systems show an eminently vertical organization (Luria, 1973a; Koziol & Budding, 2009) in which horizontal functional relationships also appear. This review allows us to distinguish two large integrated and interrelated functional complexes: a primordial-limbic complex and a supralimbic one.

**Primordial-limbic complex.** This complex consists of two large units: preferential or primordial (unit I) and limbic (unit II). In fact, Luria (1973a) was correct in integrating brainstem, hypothalamus, and limbic functions into a unique functional system. Beyond this integrated view, ontogenetic, anatomical, and functional specificities of the brainstem versus limbic systems must be recognized. Following the studies of Yakovlev (1948), unit I is related to endokinesis, while unit II is related to ereismokinesis. The hypothalamus receives and integrates external (sensory pathways) and internal stimuli (chemoreceptors, bloodstream) directly or indirectly (mainly via the limbic system). In this regard, the hypothalamus is essential for behavioral adjustments to changes in the internal or external environment (Clark et al., 2018). Thanks to these changes, the *primordial* survival of the individual is possible. At this point, it is important to comment on the relationships between type I and type II functional systems (Anokhin, 1935; Luria, 1973a). Type I functional systems act internally and unconsciously to maintain homeostasis thanks to endokinesis. The activation of type II functional systems involves three initial basic components: arousal, motivation, and reward (Luria, 1973a; Cabanac, 2010). Based on these components the supralimbic integrated functional complex (cortex-basal ganglia-cerebellum) will be activated. At this moment, the ascending neuromodulatory systems will mediate global signals to regulate the distributed functional mechanisms (type II) of the brain, specifically in the case of learning processes (Doya, 2002).

**Supra limbic complex.** This functional complex consists of the cortex (unit III) and two vertical integrated networks: basal ganglia (unit IV) and cerebellum (unit V): see *Figure 2*. As commented, this integrated network is topographically and functionally organized into three main systems: limbic, associative, and sensorimotor (Yin H. H. & Knowlton, 2006), see *Figure 1*.

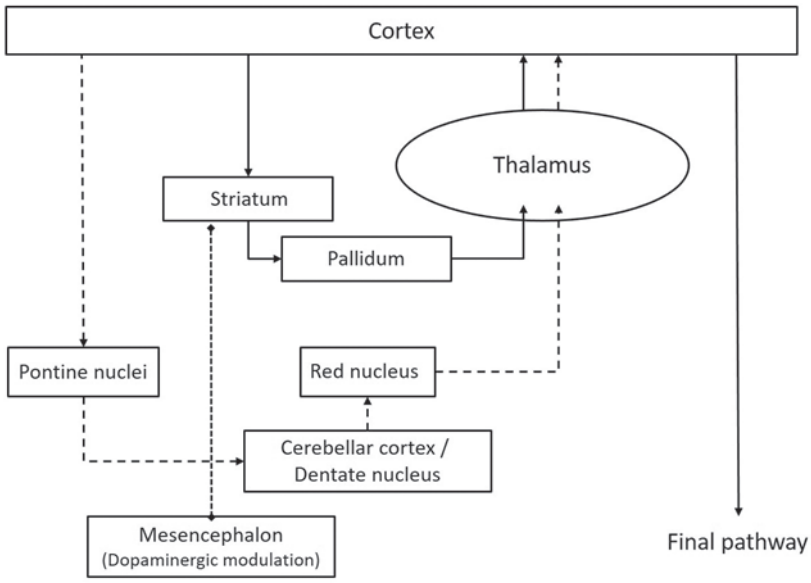


*Figure 2.* Simplified integrated parallel basal ganglia (unit IV) and cerebellar (unit V) circuits. Only the dorsal striatum is represented. Basal ganglia circuit: cerebral cortex, striatum, pallidum, thalamus, cerebral cortex. Mesencephalic dopaminergic pathways modulate striatal function. Cerebellar circuit: cerebral cortex, pontine nuclei, cerebellum, red nucleus, thalamus, cerebral cortex

There is a consensus regarding the existence of clear interplay among the cortex, basal ganglia, and cerebellum (Caligiore et al., 2017). Recent studies have also demonstrated that the basal ganglia and the cerebellum are interconnected at a subcortical level. The subthalamic nucleus in the BG is the source of disynaptic projections to the cerebellar cortex. Similarly, "the dentate nucleus is the source of a dense disynaptic projection to the striatum" (Bostan & Strick, 2018, p. 338).

**Local cortical processors and large-scale networks.** The cerebral cortex is made up of multiple hierarchically distributed local areas [processors] (*Table 3* and *Figure 1*) whose lesions give rise to classical cerebral focal syndromes (see the classic work of Luria, 1973a, and Mesulam's approach, 2000). Local cortical areas (with some exceptions) form parallel cortico-subcortical circuits that show an anatomical and functional continuum (see *Figure 3*).

In addition to local processors, the cerebral cortex displays an intense network of local, lobar, intrahemispheric, and interhemispheric horizontal connections (Catani & Thiebaut de Schotten, 2012). It is also important to highlight here the distinction between ventral and dorsal processing pathways (Ungerleider & Mishkin, 1982) in the visual, auditory, and somatosensory systems.

Beyond strict anatomy, seven coarse patterns of *functional connectivity* (networks) have been described within the human brain: visual, somatomotor, dorsal attention,

ventral attention, limbic, frontoparietal, and default mode (Yeo et al., 2011). The neuroanatomy and connectivity of these brain networks, which include vertical connections with the basal ganglia and cerebellum, are crucial to delineate a functional brain model. The default mode network includes the medial PFC, temporoparietal junction, lateral temporal cortex, posterior cingulate cortex, and inferior frontal gyrus (Spreng & Andrews-Hanna, 2015). This network is linked to various modes of self-generated thought, consciousness, and mental orientation in person, space, and time (Di Perri, Stender, Laureys, & Gosseries, 2014; Peer et al., 2015).

**Superlearning.** As previously commented, there are several different learning mechanisms acting within the brain: unsupervised, reinforcement, and supervised (Doya, 2000b, 2002). It is also crucial to propose a model for memory systems based on processing modes rather than consciousness (Henke, 2010). It is currently recognized that "brain areas form

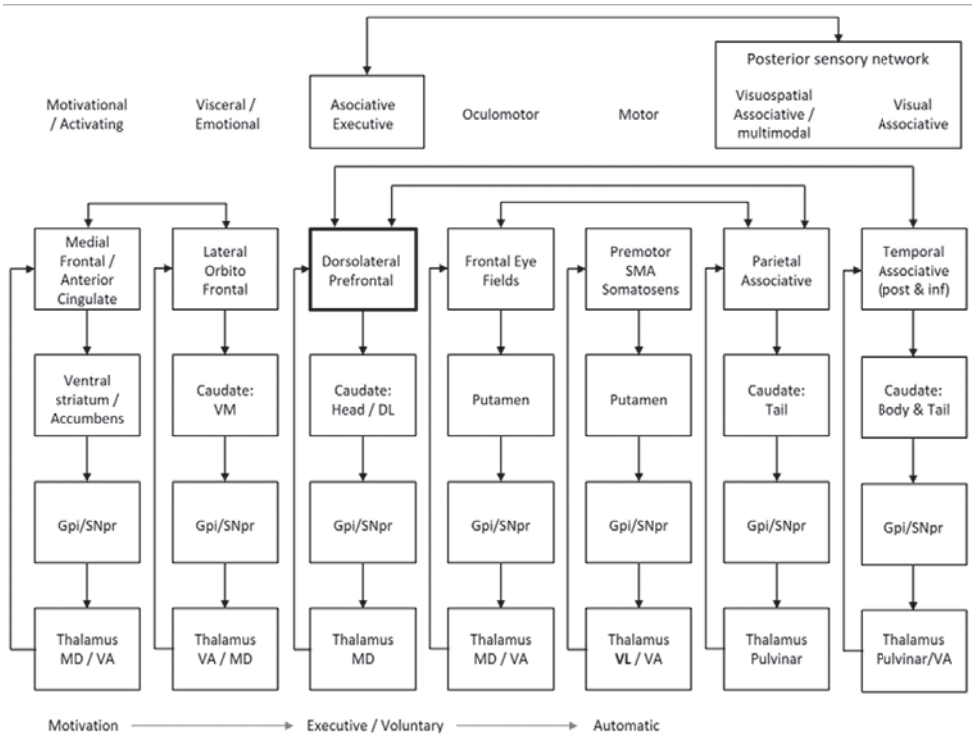


*Figure 3.* Representation of multiple parallel cortico-striatal-thalamic circuits (columns). Five frontal networks (left) and two posterior networks (right) are shown. The cerebral cortex is made up of local processors (rows 1 [functions], and 2 [cortical areas]). Cortico-cortical connections are established through association pathways (bidirectional horizontal connections). The posterior sensory processing network (parieto-temporal) connects with the dorsolateral prefrontal cortex (they constitute the executive fronto-parietal network). Bottom: topographic changes during learning (shifting from executive/voluntary networks to sensorimotor networks). After Koziol and Budding (2009), Kim and Hikosaka (2015), Seger (2006, 2008), Yin H. H. and Konwlton (2006), and Cummings and Mega (2003)

a highly integrated system, combining different learning mechanisms into an effective super-learning process supporting the acquisition of flexible motor behavior" (Caligiore, Arbib, Miall, & Baldassarre, 2019, p. 19). The concept of super-learning refers to the fact that different learning mechanisms act as a global synergistic functional system across the cortex, cerebellum, and basal ganglia (Caligiore et al., 2019).

In computational theories of acquisition of goal-directed behaviors, and specifically in reinforcement learning, establishing "how to set the different parameters of learning algorithms such as the speed of learning, the size of noise for exploration, and the time scale of prediction of future reward" is key (Doya, 2002, p. 495).

The parameters that globally affect the way many functional system parameters change by learning are called metaparameters or hyperparameters. Metalearning represents the "capability of dynamically adjusting its own metaparameters of learning" (Doya, 2000b, p. 495). The specific functional computational characteristics, and the reciprocal influences between the three learning processes, are influenced by the ascending neuromodulatory systems (unit I) (Doya, 2002).

Learning implies a shift (see *Figure 3*, bottom) from goal-directed behavior (association cortex, rostral basal ganglia) to automatic skills (sensorimotor cortex, caudal basal ganglia) (Kim & Hikosaka, 2015). See also Seger (2006, 2008).

There is evidence that large scale brain connections play a key role in semantic maps and semantic cognition (Huth, de Heer, Griffiths, Theunissen, & Gallant, 2016; Lambon-Ralph, Jefferies, Patterson, & Rogers, 2017; Friederici, 2011; Pulvermuller, 2013).

**Functional systems and neuropsychological assessment.** The concept of "neuropsychological factor" (Luria, 1973a) refers (1) to the neurological impairment of a local brain area (a local processor), and (2) to the associated psychological phenomena. See Mikadze, Ardila, and Akhutina (2018) for more information. In fact, the concept of neuropsychological factor couples aspects of cognitive functioning with brain anatomy (Mikadze, 2011). Thus, qualitative symptom analysis is considered crucial in order to establish a correspondence between symptoms and lesion localization (Mikadze et al., 2018). Beyond these considerations, it is possible to integrate and combine qualitative and quantitative assessment approaches (Glozman, 1999, 2018). Advances in the knowledge of the biological foundations of complex functional systems should contribute to a refinement of neuropsychological assessment. This review highlights a new anatomical and functional approach in the syndromic analysis of brain lesions.

## Conclusions

In summary, this paper attempts to describe the anatomical aspects of a functional brain model that develops Luria's ideas (Peña-Casanova, 1989). Functional units are abstractions within the global and integrated function of the brain. These abstractions are built on the basis of ontogenetic, anatomical, histological, functional, and clinical studies. As Luria (1973a) advanced, functional units show clear interaction among each other. Certain

structures (e. g. neuromodulatory systems, hypothalamus, and paralimbic cortex) form functional links between units. It is now recognized that functional interaction is very evident in the case of the cortex, the basal ganglia, and the cerebellum. Future studies are required to develop and improve the proposed model.

### Limitations

This paper has several limitations: it tries to establish components in a functional system that is global, the review has basically focused on anatomical structures. Space limitations have not allowed some details and certain issues have been left out.

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# Lurian Approach and Neuropsychology of Creativity

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# Луриевский подход и нейропсихология творчества

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**Background.** Alexander Romanovich Luria (1902–1977) is a widely recognized authority, attributed with the birth and development of neuropsychology. Reading the list of Luria's publications makes us aware of the wide range of his interests: from the brain location of mental functions, through methods of rehabilitation and education, cognitive processing, issues of language, intellectual development or the impact of culture on human development, to intercultural research, and consequently to the neuropsychology of creativity. The purpose of this article is to show the link between Luria's approach and the neuropsychology of creativity, and to demonstrate that a process thinking, taking into account brain/mind state, offers a new way of conceptualizing different approaches to creativity, which can be a step toward their unification, bringing into relation the continuum of passage in nature to a transition from repetition to innovation to genius.

**Objective.** The aim of the present paper is to present the brain mechanisms of creativity. It discusses the neuropsychology of creativity as a subdiscipline developing on the borderline of: (1) medical neuroscience — using clinical and experimental neuroanatomical, neurophysiological, neurobiological, neurosurgical, neurological, neuropsychiatric and (2) social neuroscience — using social psychology and neuropsychology, social linguistics and neurocultural studies to help disabled people. Special focus is placed on the functioning of artists with various forms of brain damage. The relationships between brain damage and the quality of creation are also discussed. In addition, a review of opinions of various authors from around the world on the relationship of the healthy and the damaged brain with creativity is presented in the paper.

**Case study.** Described also are ways to avoid pitfalls in the interpretation of works of art taking into account Luria's syndrom analysis. While studying the neurological and neuropsychiatric basis of the creativity of people with various brain injuries, one should take into account the possibility of the co-occurrence of syndromes as well as the overlapping of symptoms. The paper presents a case history of the illness of an artist that illustrates the importance of performing a syndrome analysis based on the Lurian approach. It also indicates the significance of supporting any neuropsychological assessment with the use of neuromarkers to avoid arriving at a false diagnosis. In the case of the patient described neurophysiological studies (neuroimaging studies of the brain, quantitative electroencephalography (qEEG), event-related potentials (ERPs) and standardized Low Resolution Electromagnetic Tomography (sLORETA) have proved to be very useful in the confirmation of his neuropsychological and neuropsychiatric diagnosis.

**Conclusions.** The paper has presented data confirming the importance of Luria's approach in the development of the neuropsychology of creativity. It was also an attempt to explain why we create, and what goes on in our bodies and minds when we begin to explore creative possibilities. Art in all of its manifestations (visual art, music, literature, dance, theater, and more) is an important feature of human societies in both norm and pathology, and therefore deserves further study.

***Keywords:*** *brain damage; brain injury; schizophrenia; neuromarker; art; self; culture***.**

**Краткое введение.** Александр Романович Лурия (1902–1977) является широко известным ученым, чье имя связано с зарождением и развитием нейропсихологии. Труды А. Р. Лурия свидетельствуют о широте его исследовательских интересов: от изучения умственных функций мозга до разработки методов реабилитации и обучения, когнитивной обработки, анализа проблем, связанных с языковым, интеллектуальным развитием, влиянием культуры на развитие человека, межкультурными исследованиями и нейропсихологией творчества. Цель данной статьи — описать связь между подходом А. Р. Лурия и нейропсихологией творчества и показать, что процессное мышление (с учетом состояния мозга/сознания) представляет собой новый способ концептуализации различных подходов к творчеству. Это может быть определенным шагом к их объединению (унификации).

**Цель.** В статье рассматривается нейропсихология творчества как дисциплина, которая развивается на стыке (1) медицинской нейробиологии, с использованием клинических и экспериментальных нейроанатомических, нейрофизиологических, нейробиологических, нейрохирургических, неврологических, нейропсихиатрических исследований, и (2) социальной нейронауки, с использованием данных социальной психологии и нейропсихологии, социальной лингвистики и нейрокультурных исследований, ее цель — помочь людям с ограниченными возможностями. Особое внимание уделяется деятельности художников с различными формами повреждения мозга. Нейропсихология творчества специализируется на изучении взаимосвязей между креативностью, функционированием мозга (структурами и связями) и индивидуальным самовыражением на основе социального и культурного сознания, а также

моделированием этих типов поведения по отношению к биологическим организмам, социальной и культурной среде. В статье прослеживается связь между повреждением мозга и качеством творчества. Подчеркивается, что язык и искусство являются коммуникативными системами, основанными на символическом и референциальном познании, при этом язык более чувствителен к повреждениям мозга, чем творческие функции. Представлен также обзор точек зрения различных исследователей относительно связи здорового и поврежденного мозга с творчеством.

**Пример из практики.** В статье описаны способы избежать трудностей при интерпретации произведений искусства с учетом синдромологического анализа Лурия. При изучении неврологических и психоневрологических основ творчества людей с различными повреждениями головного мозга следует учитывать возможность одновременного возникновения синдромов и совпадения симптомов. Представлена история болезни художника, которая иллюстрирует необходимость проведения синдромологического анализа, основанного на подходе Лурия. Это также указывает на важность проведения любой нейропсихологической оценки с использованием нейромаркеров, чтобы избежать ложного диагноза. В представленном случае нейрофизиологические исследования: нейровизуальные исследования головного мозга, количественная электроэнцефалография (qEEG), связанные с событиями потенциалы (ERP) и томография (sLORETA), оказались очень полезными для подтверждения нейропсихологической и нейропсихиатрической диагностики пациента.

**Выводы.** В статье представлены материалы, подтверждающие важность подхода А. Р. Лурия при изучении нейропсихологии творчества. Предпринята попытка объяснить, почему мы занимаемся творчеством, что происходит в наших телах и умах, когда мы начинаем применять творческие способности. Искусство во всех его проявлениях (изобразительное искусство, музыка, литература, танцы, театр и т. д.), как норма, так и патология, является важной особенностью человеческих обществ и поэтому заслуживает дальнейшего изучения.

***Ключевые слова:*** *повреждение мозга; мозговая травма; шизофрения; нейромаркер; искусство; “я”; культура.*

## Introduction

Alexander Romanovich Luria (1902–1977) is a widely recognized authority attributed with the birth and development of neuropsychology. This author often pointed to difficulties in understanding the relationship between the material body and the immaterial mind (Luria, 1976). The development of neuroscience now allows us to come closer to understanding the essence of this relationship (Glozman, 1999, 2013; Homskaya, 2001). Particular attention is paid here to the operation of the brain, with clinical neuroscience, and especially neurocultural studies, enabling one to go beyond brain processes and take into account not only the psychological and social, but also the cultural perspective (Pąchalska, Bednarek, & Kaczmarek, 2020).

Reading the list of Luria's publications makes us aware of his wide range of interests: from the brain location of mental functions, through methods of rehabilitation and education, cognitive processing, issues of language, intellectual development or the impact of culture on human development, to intercultural research (Luria, 1932, 1961, 1962, 1963, 1966, 1968, 1970, 1973, 1975, 1979, 1984; Neil, 2000). Particularly unusual at that time seems to be the broad view and ability to see new things that no one had paid attention to before. These include Luria's research on the cultural determinants of mental processes (Brown, 2020). This is one of the lesser known scientific areas of his interests, as indicated by Cole (1990) in the article entitled "Aleksandr Romanovich Luria: Cultural Psychologist". In an insightful presentation of his mentor's cultural interests, Cole points out the links between Luria's approach and the thought of Wilhelm Wundt (1874). This applies especially to the so-called psychology of peoples ("Völkerpsychologie"), created by Wundt. Luria, like Wundt, emphasized in his scientific activity that true knowledge of human nature is possible through the study of man's creations and the culture in which he lives, i. e., religion, language and myths. It is fascinating that after many years we are to discover the scientific romanticism of this great scholar, which actually brings closer an understanding of the essence of humanity (Sacks, 1990; Kaczmarek, 2001; Pąchalska & Kaczmarek, 2012).

It was Luria himself (1979) who taught us that man is a unique human being, with unique emotional, cognitive and social abilities that result from both biological, cognitive and cultural conditions. Man is the only organism living on Earth, capable of transforming the world thanks to specific forms of activity, such as science, inventions, literature, art (music, painting, theater, dance), sport and others (see also Geertz, 1962; Piechowski-Jozwiak & Bogousslavsky, 2013). Although his basic processes: that is attention, memory, perception, imagination and learning ability make him similar to other primates, he is distinguished by his unique ways of using these abilities, resulting in spectacular achievements. What allows man to develop an amazing mind and transmit culture is his social nature and social practice (Kaczmarek, 1999).

This vision of man and his capabilities is specific to Luria's clinical thinking. It contributes to a better understanding of the relationship between the brain and cognitive, emotional, adaptive and social behavior as well as with the cultural environment. It defines the self and world relationship, with particular emphasis on perception processes (how we see ourselves and the world, what we feel, how we think, what decisions we make) and actions (what and how we say and what and how we do) by modeling the brain organization. It is the creative potential of each person that connects them to the cultural life of the community and allows them to understand their contribution to its development (Pąchalska, 2019).

However, the development of each person's creative potential, as emphasized by Pąchalska, Bednarek, et al. (2020), depends on external conditions (social, communication, economic etc.) as well as on the functioning of the body (including the brain) and the mind of the person. Some of the body's dysfunctions do not necessarily have to affect creative possibilities, sometimes they can — on a compensation basis — affect their strengthening (as happens, for example, with the musical abilities of the blind). In most cases, however, the damage and dysfunction of body organs affect various types

of disturbances in creative processes. This happens especially in the case of brain damage (cf. Pąchalska, 2007, 2008, 2019).

## The Neuropsychology of Creativity

The neuropsychology of creativity, until now, has been considered the science of the relationship between brain and creativity. This can be explained by the fact that initially the neuropsychology of creativity was developed in close connection with neurology and neurosurgery. This is evidenced by the classic case reports of artists in the subject literature (Leischner & Pendzialek-Langer, 1974; Pąchalska, 1977, 1999, 2003, 2007, 2008; Kaczmarek, 1991; Leischner, 1991; Bäzner & Hennerici, 2007; Piechowski-Jozwiak & Bogusslavsky, 2013).

The relationship between brain disease and artistic creativity is particularly complex: neurological conditions after differentiated brain damage can lead to difficulties or even the inhibition of creative work in many areas (Sadana et al., 2017). Brain damage can also influence changes in the creative workshop, the method of creation or artistic style and lead, for example in people with an initial loss of creativity, to surprisingly innovative workshop solutions (Pąchalska, Bednarek, et al., 2020). In recent years, authors have highlighted the links between the creation process and the self system and the changes that this system undergoes as a result of various brain injuries. New research conducted in this field (Pąchalska, Bednarek, et al., 2020) allows one to redefine this term as well as the subject and purpose of research on the neuropsychology of creativity.

The neuropsychology of creativity is a subdiscipline developing on the borderline of: *medical neuroscience* — using clinical and experimental neuroanatomical, neurophysiological, neurobiological, neurosurgical, neurological, neuropsychiatric, and *social neuroscience* — using social psychology and neuropsychology, social linguistic and neurocultural studies to help disabled people, with a particular focus on artists with brain damage (Pąchalska, 1977). The subject of research on the neuropsychology of creativity is the relationship between creativity and the functioning of the brain (structures and connections) and the self using the individual, social and cultural mind and modeling these behaviors in relation to the biological organism and the social and cultural environment.[1] The goal of neuropsychological research is to understand the brain conditions of the psyche and human actions, i. e., reaching the neural basis of motivation, cognitive and emotional processes, and explaining the human behavior and neurophysiological factors conditioning our needs, aspirations, attitudes, values, and above all the brain foundations of the existence of any consciousness self and identity. The ability to create new things is not just the domain of outstanding individuals. The creative potential lies in every human being, and whether it is liberated and directed to creating things of a supra-individual significance depends on many conditions and circumstances deserving separate discussion (cf. Brown, 2017).

[1] The human brain does not work in isolation from the body and from the social and cultural environment (Luria, 1963).

## Main Features of Creativity and Creation

Creativity is a versatile and abstract human ability which has been defined in numerous ways; its most consensual definition conceptualizes it as an ability to yield products (e. g., ideas, stories, objects) that are both novel (i. e., original) and useful (Stein, 1953; Sternberg, Lubart, Kaufman, & Pretz, 2005). Cognitively, creativity has been conceptualized as a higher order thinking ability involving analysis, evaluation and synthesis i. e., the creation of new knowledge (Sadana et al., 2017; Abraham, 2018).

The main features of creativity — in all areas — *first*, are *novelty, originality* and *precursor*. This is emphasized by numerous definitions of the word, for example: creativity means a product possessing the value of novelty (cf. Brown, 2017). In other words, the introduction of something innovatively new and positive for society that goes beyond the familiar and accepted (Zaidel, 2014). However, the essence of creativity is not about creating what is not and never was in the work, but rather about re-imagining and transforming what exists and is available to everyone, the discovery of previously unnoticed connections between elements of the studied reality or a new approach to the reality presented in works of art (Pąchalska, 2007). The task of thinking differently requires generating creative, innovative responses to popular items (e. g., the use of a metal tube). The idea itself is associated with both consciousness and imagination, while searching for possible alternatives requires a greater association of meanings and memory capacity, including semantic memory (Storm & Angello, 2010). Accordingly, Boden (2013) has divided creativity due to product type into:

- *psychological creation* (close in terms of subjective creativity) leads to new creations only for the author;
- *historical creation* (close to objective creativity), which is new throughout history.

*The second,* and also an important feature of creativity, is *functionality*, sometimes also called utility in the broadest sense. The result of creativity cannot be useless and it is difficult to imagine the situation of creating anything without — even vague and indefinite — the idea of the function of a new product (Brown, 2017). This means that the effect of creative activity is to meet specific needs in a way better than the existing ones, sometimes it can even make/evoke the needs not previously known and not felt. It has long been believed that all creativity is intended to multiply good (in the broadest sense) and prevent evil (Pąchalska, 1977; Williams K. J. H. et al., 2018). However, also creating seemingly useless things, if it adds a new thread to the resource of good things, promotes development, self-realization, well-being, and even gives pleasure in creating. Creative activity is a way to develop a lifestyle based on self-creation and self-realization (Pąchalska, Bednarek, et al., 2020).

*The third***,** also an important feature of creativity, is *communication*. Kaczmarek (1991) has stated that a symbolic communicative system practiced only by humans, and is argued to have become a fully practiced behavior at a time when early human social groups grew in size and complexity, and communication through language and art promoted cohesion and survival. Luria (1976) pointed out that the roots of creativity reach deep and go beyond

communication and social contexts. He assumed that the basic biological needs of animals, the need to preserve physical energy and survival, the occurring threats (illness or death) can be the main motivators of innovation also in art. Given the adaptive evolutionary processes, it is reasonable to assume that these needs have been woven into the brain's creativity mechanisms in humans (Brown, 2017). This means that there is a deep motivation to communicate through art, even if there is no language communication after brain damage. In such neurological cases, the very transition to creation is innovative, but the final product is not necessarily a work of art (Pąchalska, 2007; Zaidel, 2013a, 2013b, 2013c).

## The Essence of the Creative Process

The creative process is a weave of unconscious and conscious dynamic states of mind, the essence of which is the artist's search for "non-existent" objects, including signs and their meanings, followed by their processing and final execution of the work. As was stated by Pąchalska, MacQueen, and Brown (2012) the central property of an original act and the crux of creative thought is a departure from habit or expectancy. This could be construed as a failure of repetition since each recurrence is minimally novel in comparison to its antecedents, in part due to changing sensibility, in part to fluctuations in the resting state. Incessant change is introduced along with continuity in the revival of mental states, in the growth of private experience and the passage of objects in the world. The continuity resolves the sameness of things with novelty in their recurrence. Whether a thing changes rapidly — a film, an argument — or slowly — the self, a rock: the transition over moments is continuous. The paradox is that in spite of continuity, things exist as a single brain/mind state (epoch) of becoming with no gaps in experience or perceptible nature.[2] Things recur and each recurrence is novel though retaining ingredients of the prior single brain/mind state (epoch). The difference between exact iteration, novelty in passage and fresh renewal depends on more than a difference in succession since a world in continuous change is the main source of the disparity, and a self of moderate stability is the arbiter of sameness and difference (see also Brown, 2017).

In this context it is important to emphasize again that genuine change occurs in the actualization of the brain/mind state (epoch), and that apparent or illusory change occurs in the transition of one brain/mind state (epoch) to another. Genuine change is the becoming-into-being (existence) of an entity — the actualization of a sequence of categories — while apparent change is the progression from one brain/mind state (epoch) of being to another, namely, the observed and presumed causal sequence of events in the world. An epochal state is an instance of being that is inert, its dynamic — becoming — exhausted in its formation. The process of entity creation is complete on the actualization of an epoch of being (category, substance), which on achieving existence passes away in its replacement, while continuity depends on the overlap of epochs (see *Figure 1*).

[2] Even across sleep or loss of consciousness there is felt a continuity of the self.

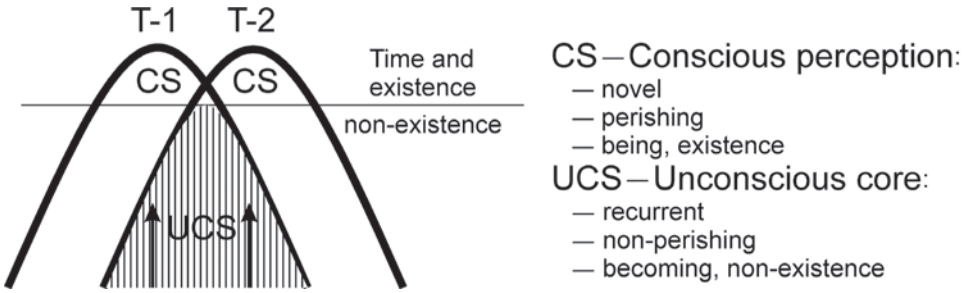


*Figure 1.* Phases in working memory are generally revived in ensuing states in the order of their registration, i. e., in relation to their resemblance to the oncoming brain/mind state and, thus, their capacity for revival. Images closer to the current perception, i. e., those in short-term memory that almost achieve re-perception, are most likely to be revived in the current metal state. The brain/mind state at T-1 is replaced by an overlapping state at T-2. The core of T-1 is overlapped at T-2 before T-1 terminates, i. e., before the epoch exists. This explains the recurrence of early phases in T-1 associated with individuality, self, character, dispositions, long-term and experiential memory, and the "persistence" of core beliefs, values and personality. Later phases perish on completion of the entire state to make way for novel perceptions. There-activation of earlier phases by the overlapping state explains the sustained personhood behind succession. Early phases are an ingredient across states, later ones are malleable to a greater extent as the endogenous process is shaped by sensation.
S o u r c e: Pąchalska et al., 2012

The brain creates ideas based on insights. The duration of the image depends on a whole range of features, where emotions play the main role. Pleasant events are subjectively perceived as shorter (e. g., meeting with a friend), unpleasant events have a subjectively longer duration (e. g., waiting in the waiting room for a dental procedure). Thus, the event has a more or less arbitrary duration in a series of repetitive brain/mind (epoch) states. The exchange rate is probably constant for each unit. The dynamics of the brain/mind state are associated with changing objects and events, and with our attitude to them. The real change in the mind of the observer is imperceptible.

## The Roots of Creativity

Looking at the fascinating creations of artistic craftsmanship, we wonder how their creators invent such "ready" works. Zaidel (2014) suggests that, given the biological and neurological basis of brain function, human creativity has at least three perspectives:

1) *biological*, which includes innovations related mainly to the needs and motivation of the individual (the roots of creativity run deep and are not necessarily limited to social or communicative considerations);
2) *neuroanatomical,* which includes innovations related to differences between individuals in the size and organization of the brain, the number and quality of neuronal connections and neurotransmitters;

3) *neurological,* which includes innovations related to the consequences of brain damage and their references in visual arts (in artists with brain damage forming various disease syndromes).

Biological underpinning, which includes mainly research on the biological foundations of creation, has been conducted for several years and concerns both animals (Hinde & Fisher, 1951; Benson-Amram & Holekamp, 2012) and humans (Zaidel, 2014). Compared to humans, however, innovations by animals are far fewer (Laland & Reader, 2010; Lefebvre, 2013). Given adaptive evolutionary processes, it is reasonable to assume that all of these have become interwoven into the underlying brain mechanisms of creativity in humans (Pąchalska, 1999; Brown, 2017). Nowadays, work is underway on the relationship between gene expression, and behavior, mainly creativity (Pąchalska, Bednarek, et al., 2020). These studies include the conclusion that a person capable of innovation is motivated mainly by biological to survive, which has been linked to other, unique creative abilities.

Neuroanatomical underpinning includes mainly the comparison of the human brain to that of monkeys with fMRI having revealed several corresponding structural and functional networks, but two that are unique to humans (Mantini, Corbetta, Romani, Orban, & Vanduffel, 2013), that is, the left hemisphere language network and the left fronto-parietal network. Using MRI for brain structural and parcellation analyses, investigators (van Essen, Glasser, Dierker, Harwell, & Coalson, 2012) have found a larger left Sylvian Fissure, which includes the parietal operculum, and in the medial temporal cortex, the portion with the lingual gyrus and collateral sulcus (all critical in language functions); in the right side the angular gyrus and dorsomedial prefrontal region. Such asymmetries are not found in other mammals, and could play a functional role in human creativity. In this trend, research is conducted on the relationship of neurotransmitters and creative activity. For example, deficiency of serotonin and related depression promotes the creation of sad works painted in black colors.

Neurological underpinning includes mainly observations of various brain damage effects on the creativity of visual artists. Approximately 80 cases or so with such damage (mainly in one side of the brain, and where the etiology is commonly stroke or brain cancer) have already been described in the neurological literature (Kaczmarek, 1991; Pąchalska, 1999, 2003, 2007, 2008; Rose, 2004; Bogousslavsky & Boller, 2005; Zaidel, 2005, 2013a, 2013c; Finger, Zaidel, Boller, & Bogousslavsky, 2013; Mazzucchi, Sinforiani, & Boller, 2013; Piechowski-Jozwiak & Bogousslavsky, 2013). They can help show the way to the neuroanatomical and neurofunctional foundations of creativity. The key questions concern post-damage alterations in creativity, as well as loss of talent, or skill (Zaidel, 2014).

However, Luria, Karpov, and Yarbus (1966), describing the multifaceted nature of the roots of human creativity, drew attention not only to the above-mentioned perspectives, but also to the system of the self and the artist's identity associated with it (cf. Pąchalska, Bednarek, et al., 2020). It is presumed, that human creativity, both healthy and with brain damage, like many other activities, is usually a response to its various needs associated with the emotional component (cf. Pąchalska, Bednarek, et al., 2020). In this context, it should be

noted that for the artist, creativity in itself is a need, often strong, that requires immediate satisfaction. The artist sees in the world the lack of something, which is a product existing so far only in his imagination. The very process of creation meets the need to fill this gap, but its satisfaction is only possible after the creation of the work or at least a part of it. Cultural patterns in the brain, which are made aware or unconscious, play a specific role here, but act in individual states of mind as a kind of internal constraint (Pąchalska, 2019).

## Objective

Research in the neuropsychology of creativity has focused on the creative process and neurocultural studies are still in their infancy. Only recently have they joined the empirical aesthetics that was introduced in the 19th century by Gustav Fechner (Fechner, 1876). It is difficult to say whether neuroscientists consider this topic worthy of deeper scientific studies, of course with rare exceptions (Pąchalska, 1999, 2019; Augustin & Wagemans, 2012; Pąchalska, Bednarek, et al., 2020).

A number of reports have examined the development of visual artistic ability following degenerative or other types of brain injury (Zaidel, 2005; Chatterjee, 2006; Pąchalska, Buliński, et al., 2013). However, the emergence of *de novo* artistic ability is rarely seen in brain-damaged patients (Pąchalska, 1977; Pollak, Mulvenna, & Lythgoe, 2007; Piechowski-Jozwiak & Bogusslavsky, 2013); this is particularly true for patients with traumatic brain injury (Schott, 2012; Grochmal-Bach et al., 2009; Midorikawa & Kawamura, 2015), autistic patients (Sacks, 2004; Baron-Cohen, Ashwin, E., Ashwin, C., Tavassoli, & Chakrabarti, 2009), schizophrenia (Pąchalska, Grochmal-Bach, MacQueen, et al., 2008) or stroke (Pąchalska, 1988; Pąchalska, Grochmal-Bach, Wilk, & Buliński, 2008; Kaczmarek, 1991; Kaczmarek, Code, & Wallesch, 2003; Code, Joanette, Lecours, & Wallesch, 2003).

The aim of the present paper is to present the brain mechanisms of creativity. It discusses the neuropsychology of creativity as a subdiscipline developing on the borderline of: (1) medical neuroscience — using clinical and experimental neuroanatomical, neurophysiological, neurobiological, neurosurgical, neurological, neuropsychiatric and (2) social neuroscience — using social psychology and neuropsychology, social linguistics and neurocultural studies to help disabled people. In addition, a review of opinions of various authors from around the world on the relationship of the healthy and the damaged brain with creativity is presented in the paper.

## Case Study

When describing the neurological and neuropsychiatric basis of the creativity of people with various brain injuries, one should take into account the possibility of the co-occurrence of various disease syndromes or the overlapping of symptoms one on another. That is why good syndrom diagnosis as initiated by Luria (1976) is extremely important, sup-

ported, if possible, by the designation of the neuromarkers of a given disease entity since very often we are dealing with false diagnoses (Pąchalska, Kaczmarek, & Kropotov, 2014).

It is well known that brain damage can lead to various focal and generalized neurological disorders. There is, however, only one report on the potential changes in artistic output following multiple disorders, that is schizophrenia complicated with head injury and post-traumatic depression (Pąchalska, Grochmal-Bach, MacQueen, et al., 2008; Pąchalska, Grochmal-Bach, Wilk, et al., 2008). He was a well-established painter (WW, born in 1940), who was diagnosed at the age 18 with schizophrenia. As a part of psychiatric rehabilitative therapy, he received art therapy, during which he developed sophisticated painting skills, enabling him to become a successful painter widely recognized by critics. He portrayed his own visual hallucinations (see *Figure 2*), mainly using recollected contents rather than active/ongoing visions, when painting.

*Figure 2.* Painting entitled "Laboratory" created before the accident based on the artist's visual hallucinations.
S o u r c e: clinical material of M. Pąchalska

One day, while actively hallucinating and feeling able to fly with wings, he rushed into the street and was knocked down by a car. He was unconscious for 5 hours, with a brain injury involving the subcortical anterior frontal areas, and with subsequent asymmetric frontal lobe atrophy predominating on the left side (see *Figure 3*).

After the injury, his painting style changed with a significant reduction in the hallucinatory content. The subjects became more traditional with a selection of hues now dominated by blunt and earthy colors. He also showed signs of perseveration in repeating the reproduction of the same objects or faces.

Over time, his psychiatric condition deteriorated and 10 years after his accident, he had another psychotic burst, also with progressive memory disorder. On detailed neuropsychological assessment, he showed visual memory deterioration, executive dysfunction, and hemispatial neglect (see *Figure 4*).

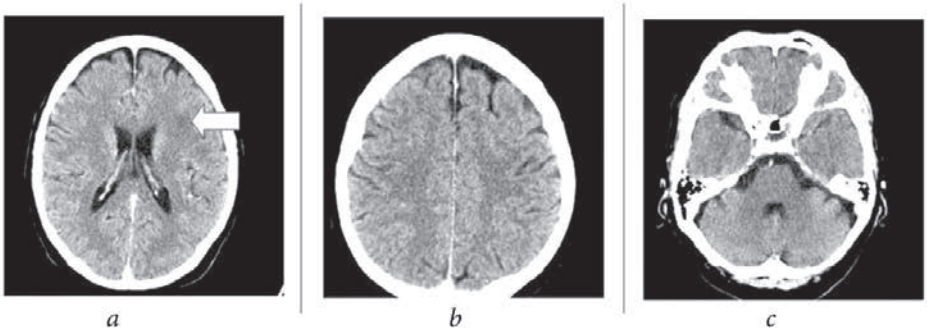


*Figure 3*. Computed tomography of the brain done 15 years post trauma: *a* — arrow shows a hypodense subcortical left frontal lesion; *b* — asymmetrical cortical atrophy more pronounced on the left; *c* — right anterior temporal lobe and cerebellar atrophy.
S o u r c e: clinical material of M. Pąchalska

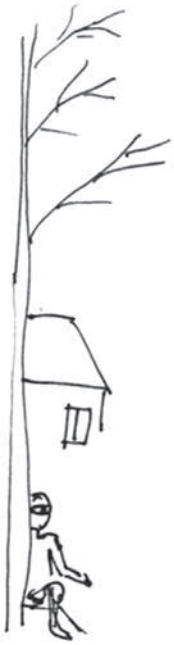

*Figure* 4. A drawing of a person, a house, and a tree showing left hemispatial neglect.
S o u r c e: clinical material of M. Pąchalska

The patient took part in an intensive cognitive neurotherapy program run for two years, four times a week. Transcranial direct current stimulation (tDCS) was used to reduce depression in combination with the Therapy of Symbolic Thought (see Pąchalska, 1977, 1991, 2003; Kaczmarek, 1991). After a year of therapy, significant improvement in all cognitive functions was obtained. In the painting, the features of side skipping disappeared, but the patient was still signaling his sadness and social isolation (see *Figure 5*).


*Figure* 5. A drawing of "my illness" showing sadness and social isolation. In the right corner the artist wrote "a bird came to advise on something".
S o u r c e: clinical material of M. Pąchalska

The inscription on the engraving "a bird came to advise on something" and the subsequent interpretation of the work by the artist suggests that only a bird can advise on something, because people do not understand his sadness and social isolation.

## Prevalence of Depression and Schizophrenia Neuromarkers

Neurophysiological studies (neuroimaging studies of the brain, quantitative electroencephalography (qEEG), event-related potentials (ERPs) and sLORETA tomography[3] (see Kropotov, 2009, 2016) were very useful in the confirmation of his neuropsychological and neuropsychiatric diagnosis.

A comparison of studies conducted before therapy (study 1), after a year (study 2) and after two years of using neurotherapy (study 3) shows significant (even spectacular) changes in the EEG spectra that occurred during all three recordings (see *Figure 6*).

It is noteworthy that in the first recording conducted in the examined patient before therapy, slow alpha (about 8 Hz) rhythms obtained from F7 and F8 sites were noted. These slow alpha rhythms reflect a statistically significant deviation from the norms in individual spectra.

[3] The studies described here are looking for the neuromarkers of mental disorders (Kropotov, 2009, 2016; Kropotov, Pronina, Polyakov, & Ponomarev, 2013; Pąchalska, Buliński, et al., 2013; Pąchalska & Kropotov, 2020). The concept of neuromarker was defined by K. J. H. Williams et. al. (2018) as a narrower version of the biomarker. In the case of EEG recordings, neuromarkers in the form of amplitude of EEG spectra and ERPs are considered to be two important factors giving insight into the functioning of the brain: spontaneous EEG recording shows the mechanism of cortical self-regulation, while ERP reflects the flow of data at particular stages of their development in the brain.

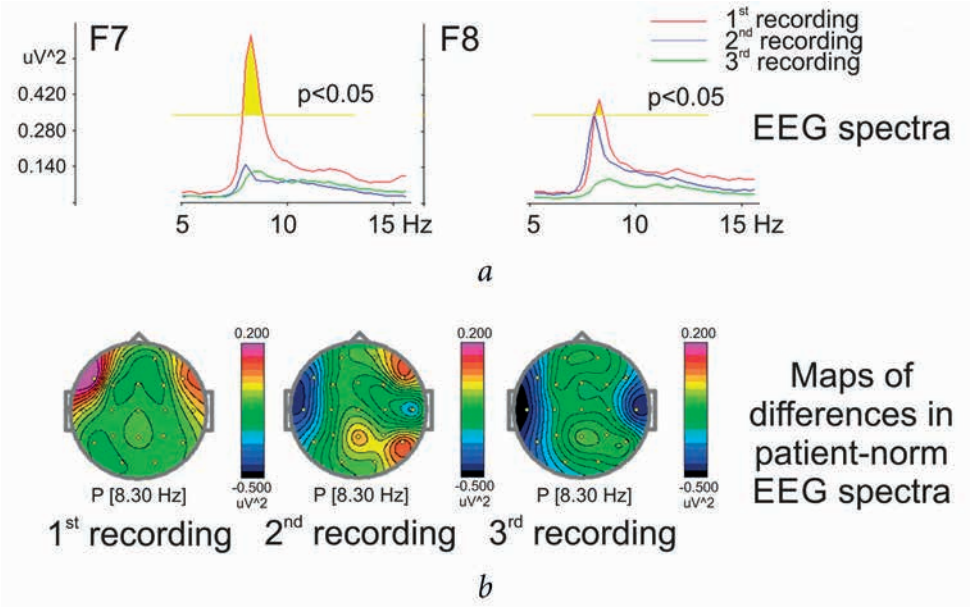


*Figure 6.* EEG spectra obtained in the GO / NOGO task in three recordings from the electrodes applied in places F7 and F8, 1st recording — red curve, 2nd recording — blue curve, 3rd recording — green curve. The peaks in the spectra obtained during the first recording correspond to an alpha rhythm of about 8 Hz. The yellow horizontal line shows the confidence level ($p < 0.05$) in the range of deviations from the normative mean (*a*). Maps of EEG spectra with a value of 8.3 Hz during three recordings (*b*).
S o u r c e: Pąchalska et al., 2014

Extracting the independent components from the spontaneous EEG recording during the first recording revealed the presence of two independent components generated in the left and right prefrontal cortex respectively (see *Figure 7*). In the second recording, there was a large loss of alpha rhythm in the left lower frontal cortex, which completely disappeared in the third recording.

Earlier research by Kropotov et al. (2013) showed that the difference in the ERP wave obtained in the record when performing NOGO-GO tasks can be considered an indicator of the cognitive control. In *Figure 8* I present the mean for ERPs wave differences in healthy subjects and in patients with diagnosed schizophrenia from the Human Brain Index (HBI) normative database in Chur, Switzerland. It can be easily observed that the difference in waves from the electrode recording at the Cz point rapidly decreases in patients with schizophrenia. It should be emphasized that the patient under discussion had a wave distribution similar (see *Figure 8*, on the right) to patients with schizophrenia (see *Figure 8*, on the left), because in all three records a clear delay or reduction of the differences between the waves is observed. At the same time, the positive wave recorded from the electrode placed at T5 did not change.

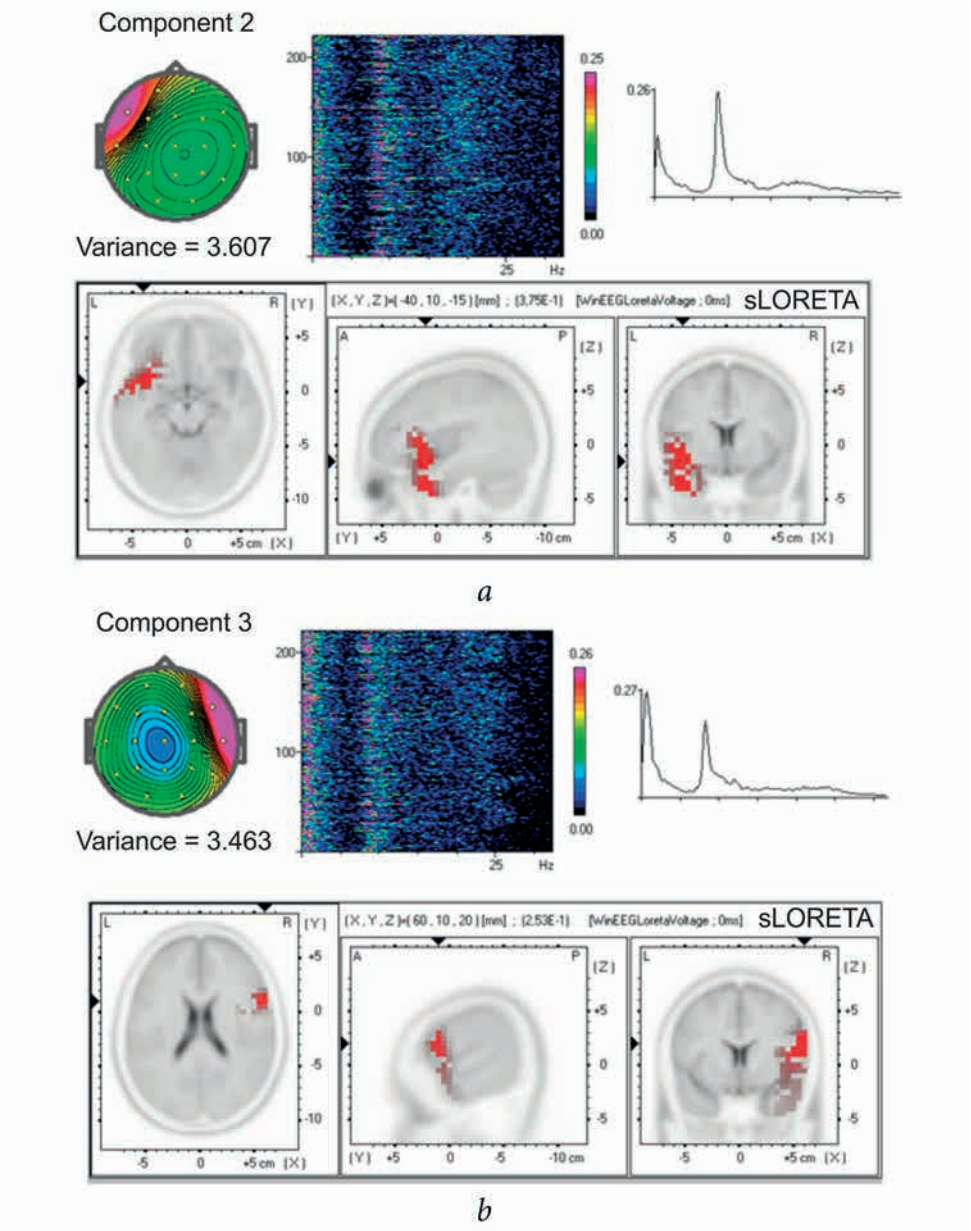


*Figure 7*. Independent components extracted from the first EEG record: *a* — independent component generated in the left hemisphere: top (*from left to right*) — topography, spectra coded for 4-second periods, calculated for the entire 20-minute recording, averaged component spectra; bottom — topography image obtained in sLORETA tomography; *b* — independent component generated in the right hemisphere: top (from left to right) — topography, spectra coded for 4-second periods, calculated for the entire 20-minute record, averaged spectra of the components; bottom — topography image obtained in sLORETA tomography.
S o u r c e: Pąchalska et al., 2014

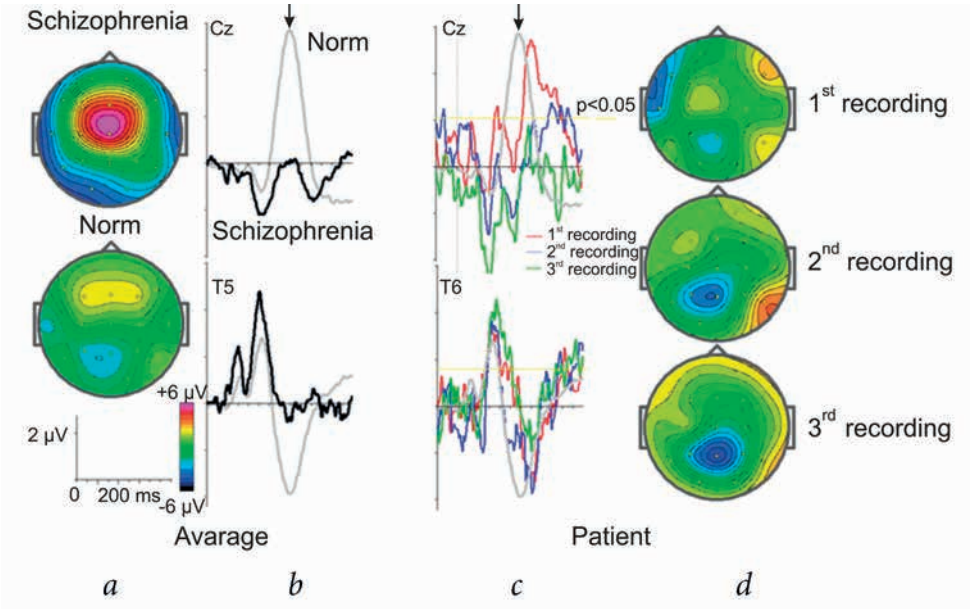


*Figure 8.* Differences in ERP waves in NOGO-GO type tasks in the examined patient in comparison with healthy individuals and schizophrenic patients: *a* and *b* — the average of ERP wave differences from the records taken from the electrodes applied at Cz and T5 points in a group of healthy individuals ($n = 61$) and a group of patients with schizophrenia ($n = 28$) selected by age, and wave difference maps at 390 ms (marked with an arrow); *c* and *d* — individual differences in ERP waves in three records made in the examined patient from electrodes applied at Cz and T5 points. Right — wave difference maps at 390 ms (marked with an arrow).
S o u r c e: Pąchalska et al., 2014

It can be therefore concluded that the studied patient had a neuromarker of disturbed cognitive control which could be an index of schizophrenia. This is associated with a decrease in ERPs wave form recording during NOGO-GO tasks. As numerous studies have shown, including mine, this neuromarker occurs in most patients with schizophrenia (Kropotov et al., 2013; Pąchalska, Pronina, et al., 2013; Pąchalska et al., 2014). At the same time, the positive wave recorded from the electrode at the T5 point did not change in study 3. This means that the Therapy of Symbolic Thought did not affect this neuromarker. This means that it can be used to confirm or exclude a diagnosis of schizophrenia (see also Pąchalska et al., 2014).

It is worth mentioning that the variability of schizophrenia symptoms (acute psychosis), cognitive deterioration and periodic intensification of symptoms associated with previous brain trauma (e. g., periodic depression) may have been related to the content and form of the subsequent paintings painted by this artist. Therefore, his artistic output change is rendered particularly complex and difficult to interpret, given the superimposition of neurological and psychiatric conditions (see *Figure 9*). This self-portrait was paint-

ed a few days after the cast of acute, transient psychotic disorders according to the ICD-10 code coding F23. During this period, the patient experienced hallucinations, delusions and perceptions. These symptoms started suddenly, had great strength and subsided after three weeks. According to the patient, the symptoms were caused by the death of a close friend. It illustrates the artist's state of mind.

*Figure 9.* Self-portrait created during the Therapy of Symbolic Thought, a few weeks after acute psychosis.
S o u r c e: clinical material of M. Pąchalska

The analysis of the work shows that various aspects of the sense of his own self have been disturbed. These include:

1) *disturbance in the sense of separateness of the self from the environment* — body fragments of the presented figure leave its borders, merging with the hallucinated external reality, and this reality breaks into its interior, blurring the boundary of the self from the outside world;
2) *disturbance of the sense of unity (identity) of one's self*, which is multiplied, gender identification is disturbed, the character has been placed in a dream-like world. Within and on the border of the body there are still other deformed figures not belonging to the real world;
3) *disturbance of the sense of coherence of the biological self*, its own body has undergone transformations. The picture shows one person representing the artist who has three faces with four eyes and three noses and lips. We also see four hands belonging to no one and mysterious, unidentified beings who invaded the open body of the represented figure;
4) *disturbances of the feeling of having internal content,* both the interior of the figure representing the artist and the background of the image are full of symbolic,

hallucinated performances whose meaning remains unclear; some symbols are religious, others refer to dream-like or esoteric (occult) phenomena.

Particularly noteworthy is the fact that subsequent images created in the process of neurotherapy did not bring about a great change in the artist's style of creation. The patient expressed his dissatisfaction with the few sketches he had made for the pictures. The breakthrough in the artist's work occurred when his work was stolen from the exhibition and in compensation he received €1000 from the organizers, which changed his self-esteem and attitude towards the images he had created. He came to the conclusion that his works were of great value. The award system launched at that time made the artist enthusiastically set about creating further works. During this time, over 30 self-portraits were created in the form of 3 heads (see *Figure 10*). In his opinion, all these paintings

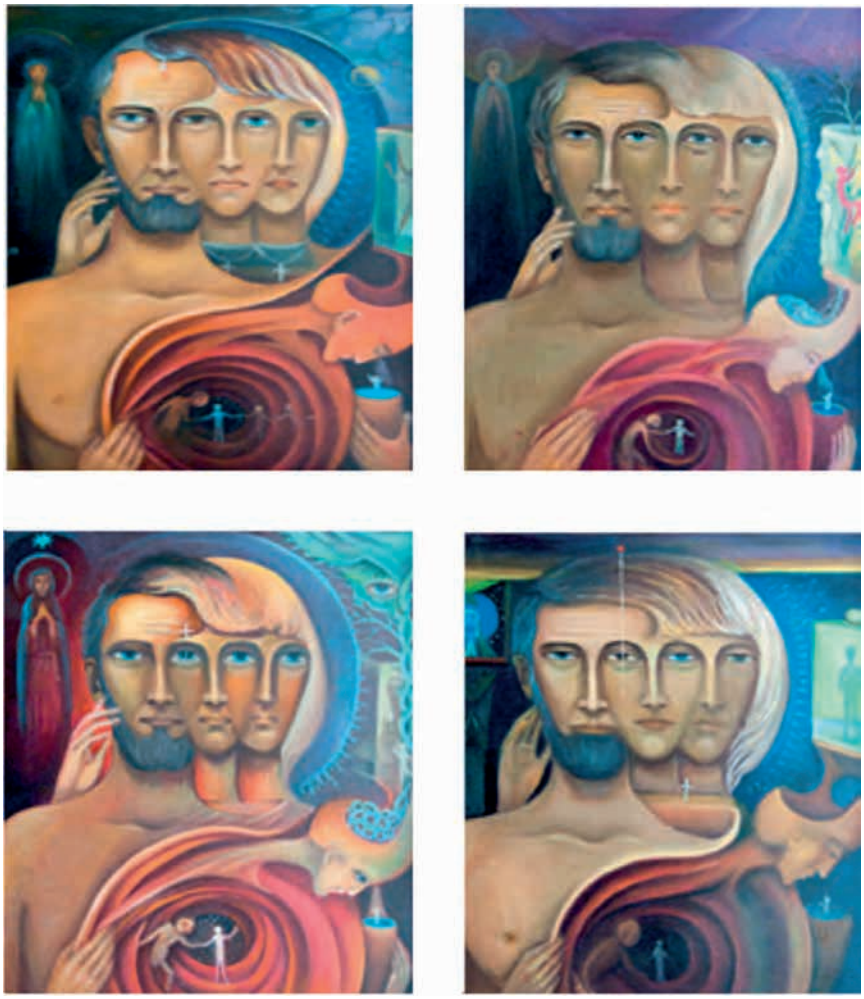

*Figure 10.* Perseverated self-portraits created during the Therapy of Symbolic Thought.
S o u r c e: clinical material of M. Pąchalska

were new and different works. The patient was very happy after painting each of these self-portraits. However, according to critics, this works resembled, to a greater or lesser extent, the first of the painted self-portraits. According to neuroscientists, these were likely to be classified as perseverations associated with damage to the brain's frontal lobes, and disturbances to the working memory.

The above example of WW patient's creativity shows us the importance of self-awareness, cognitive processes, with particular emphasis on attention and working memory), emotional and executive in creativity. It also indicates the holistic brain activity (Luria, 1976, 1979) or equipotentiality (Lashley, 1951), its holographic organization (Pribram, 1984), and even the function of the brain and mind not only in space and time, but also in a pulsating state in hyperspace (Pąchalska, 2019), presented in the author's synchronous memory model (see *Figure 11*).

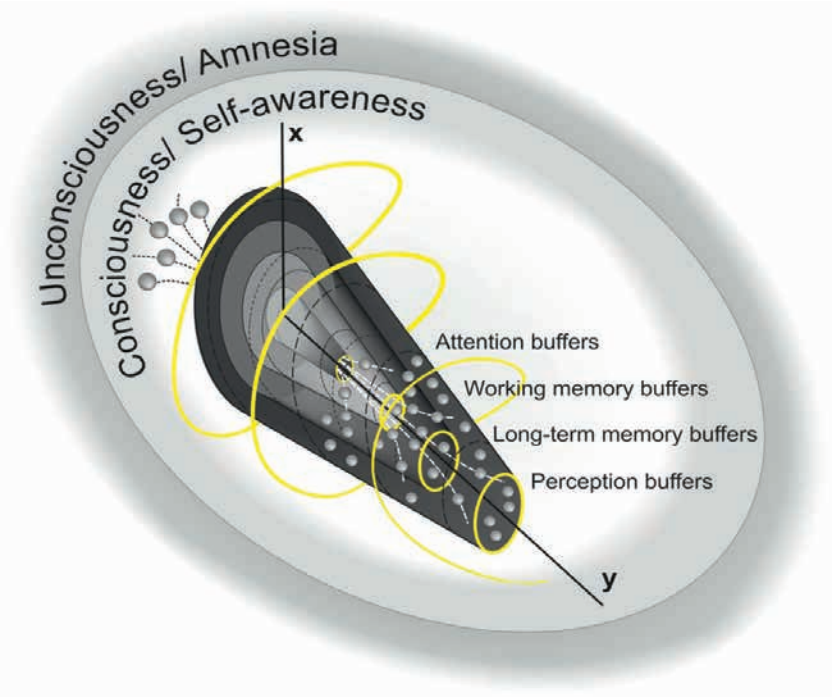


*Figure 11*. Synchronous memory model.
S o u r c e: Pąchalska et al., 2014 (modified)

The spatial arrangement of the model makes it possible to present on the *x* and *y* axes the relationship between the general structure of attention and memory systems (in terms of the number, content and complexity of the processed elements) and the period of time necessary to process them. It can be seen that the attention buffers transfer data to the working memory buffers. This system, according to the latest data obtained in neurophysiological studies, processes the smallest number of elements in the shortest possible time: seconds or even milliseconds (Kropotov, 2009; Brown, 2017). As the num-

ber of elements of information processed and/or the duration of the processing exceeds a certain threshold, we gradually move from the attention system (several stimuli, several milliseconds) to the working memory system (several to several dozen stimuli, several milliseconds to several seconds and/or minutes) depending on the capacity of the working memory buffer (see also Pąchalska et al., 2014).

In a similar way, there is a transition from the working memory system to the long-term memory system. The boundary of the transition is difficult to determine precisely and most likely it is actually not very sharp. In the human brain, a continuous process takes place, lasting from milliseconds to entire years when information is remembered, stored, reproduced and forgotten. Also, semantic and episodic memory is associated with the number, time as well as the content and complexity of the processed data (see Pąchalska, 2007, 2008). The differences between these types of memory mainly concern the content of information. Of course, the longest storage time is characteristic of long-term memory, which is why we put it at the basis of the presented model. This is closely related to the organization of one's self in time. Artists with brain damage as a result of the collapse of the memory system may change the style of creation (cf. Schott, 2012; Piechowski-Jozwiak & Bogusslavsky, 2013) but also they will not be able to change the pattern of creation and will repeat the same pattern in subsequent works (cf. Pąchalska, 2019).

Returning to the division of creativity by Boden (2013), a work created for the first time, as long as it has features of novelty, can be classified as a historical creation (close to objective creativity), which is new in the entire history of creativity, and even recognized by critics for being transgressive (Toeplitz, 1991). The perseverance mechanism associated with damage to the frontal lobes may deprive the artist of this feature and the work will have only the features of psychological creation (close in terms of subjective creativity) leading to new creations only for the author. The patient presented here claimed that he created only new works, but they were, according to critics, new only to him. It is worth noting, however, that from the patient's perspective, many factors influence such a style of creation and its assessment. Perhaps the most important factor is that the patient has difficulties in introducing a new topic to his work. However, the painted works have objectively smaller or larger differences of detail, which illustrate the varied states of consciousness experienced by this patient and painted (more or less consciously) in subsequent works. Therefore, it is difficult to state unequivocally whether we are dealing here only with perseverations and with compulsive returns to the same motif due to brain damage. Before the illness, this artist was a professional with educated skills and artistic self-awareness. He probably also knew that in the history of art there were many artists who repeatedly returned to the same motif and who built their works from repetitive elements — contrary to the common rule that the artist is required to be unique and to create unique works.

As Pablo Picasso claimed, "One would like a man not to be repeated. Repetition is against the laws of the mind, its forward course" (Toeplitz, 1991, p. 131). Therefore, it is worth taking a closer look at the functions of the repetitions used. Sometimes they were study series, in which the artist penetrated into very subtle shapes and shades

of repeated motifs, sometimes also subsequent approximations of the ideal were created in the imagination of the creator. In modern art there is even a fashion for multiplication of the theme. This included, for example, Andy Warhol (1928–1987) the well recognized American artist, one of the chief representatives of pop art, known primarily from simple and serial sets with different color contrasts, which included, for example, repeated portraits: Brigitte Bardot, Marilyn Monroe, Elvis Presley, Jacqueline Kennedy Onassis, Marlon Brando, Elizabeth Taylor. Repeatability can become one of the means of expression, fulfilling the functions of either describing the state of modern culture in which stereotype, punch and uniformity dominates, or rebellion against these phenomena, which can also be interpreted as a manifestation of transgression (Pąchalska, Kaczmarek, & Bednarek 2020).

The patient example presented above allows us to understand how difficult it is, even for an experienced researcher, to interpret the creativity of a patient with brain damage. It is necessary to take into account the patient's life history, type, place of brain damage and symptoms that have developed as a result of this damage at various periods of time, e. g., the development of post-traumatic emotional disorders, frontal syndrome, including depression and anxiety, and the destabilization of the self system (Pąchalska, Kaczmarek, & Kropotov, 2020). Therefore, one would have to agree with Luria et al. (1966) that the process of creation is closely related not only to the functioning of the brain, but also to the proper functioning of the individual self system, including the social and cultural one. It depends on the integration and interaction of all types of self and it is closely related to the process of creation.

## Integrated Self System and Creativity

Integrated self system included the individual (objective and subjective) and social (collective and cultural) self (Pąchalska, 2019; Pąchalska, Kaczmarek, & Bednarek, 2020). This concept, however should include the minimal (working) and longitudinal (autobiographical) self, which is the basis for the formation of the self system. Therefore, I have developed a modified model of the self system, which requires the nesting of the minimal (working) and longitudinal (autobiographical) self and a change in understanding of the concepts of individual and social self in terms of the thought process (see *Figure 12*). Therefore:

1. The individual self includes:

- the objective self, understood as the organism, i. e., in Goldstein's (1995) approach, the body together with its states and processes occurring in it. The subject self has consciousness, but it lacks self-awareness and meta-consciousness (awareness of mental operations on its own subject). The subject does not express their own thoughts but acts according to ready-made schemes: he/she is not the author of the selves. As soon as you realize the existence of the outside world, your subject self also becomes the object of perception. This process enables the subjective self to be formed;

- the subjective (cognitive) self, having consciousness, self-awareness and meta-consciousness, enabling one to know oneself and act in accordance with one's own needs and values as well as the requirements of the environment. He/she has a sense of separateness, autonomy, insight (introspection), the possibility of self-assessment and self-control and creativity (see Pąchalska, 2008). The subjective self conditions the appearance of individual identity.

2. The social self, includes:

- the relational self, understood as an image and description of the You — You (interactions), from an individual and social perspective taking into account relationships with other important people and social groups around which, according to Richard Brown (1987), social identity develops.

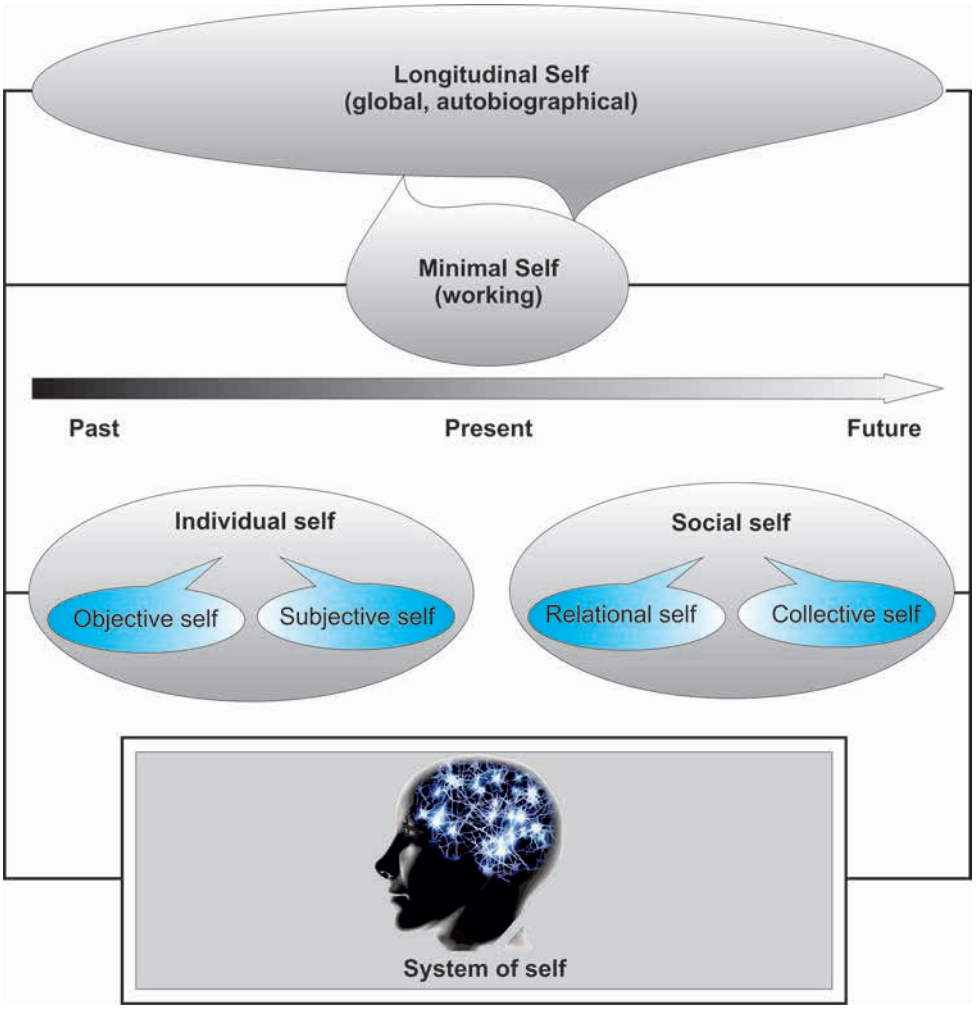


*Figure 12.* Process model of the system of self (modified).
S o u r c e: M. Pąchalska, 2019

- the cultural self, understood as an image and description of the We — We from an individual and social perspective including nesting in the culture or subculture of a given social group around which cultural identity develops.

The microgenetic approach to the self-system takes into account the concept of the nesting of the minimal (working) and longitudinal (autobiographical) self in the individual and social self in the processual approach, and creates the basis for the development of the self system. It also allows for a better explanation of the disruption or disintegration of this system in people with various kinds of brain damage. It also allows for more effective rehabilitation interactions to be offered to these people (see also Prigatano, 2009).

People with brain damage exhibit disturbances in logical or spatial coherence depending on the location of the damage (structures and neural connections) in the right or left hemisphere of the brain. Linguistic representations are more or less disintegrated, which makes creating language constructions more difficult, as a result of which the process of creating ideas about yourself and the world is disturbed, which is why the image of oneself and, as a result, the whole system of the self is disintegrated. Damage to the subcortical structures and connections is also not without significance, however, the picture of disorders is different, something which is described in more detail as detailed in another work (Pąchalska et al., 2014).

**What Drives Anyone to Create?**

What goes on in our bodies and minds when we begin to explore creative possibilities? What was the feeling that made a particular person want — so deeply — to create something almost randomly? What in the brain triggers the moment of "rising above" established knowledge, and why are some individuals exceptionally creative: are all questions that are still being explored (Barbey, Colom, & Grafman, 2013; Jung & Haier, 2013). At the same time, several creativity-related factors have already been identified, specifically brain size in innovative animals (Lefebvre, Reader, & Sol, 2004), neurotransmitters (Manzano, Cervenka, Karabonov, Farde, & Ullen, 2010), intelligence level (Lefebvre, Reader, & Sol, 2013; Brown, 2017), ecological niches (Lefebvre, 2013), personality and identity attributes (Pąchalska, 2019).

One of the most important factors, without a doubt, is social recognition variously understood, which activates and strengthening the reward system (see *Figure 13*).

Pleasant experiences release positive emotions (e. g., joy), because they stimulate the reward system by creating connections from the basal part of the frontal cortex to the anterior (emotional) part of the anterior cingulate cortex of the right and the left haemisphere. At the same time, the punishment system is weakened. The strength and duration of these emotions are associated with the importance of the event for the artist. Therefore, exhibition, and the positive reactions of the audience, might modify the minimal (working) self, and the longitudinal (autobiographical) self, strengthening the significance of a given (negative or positive) event (see Pąchalska, 2019).

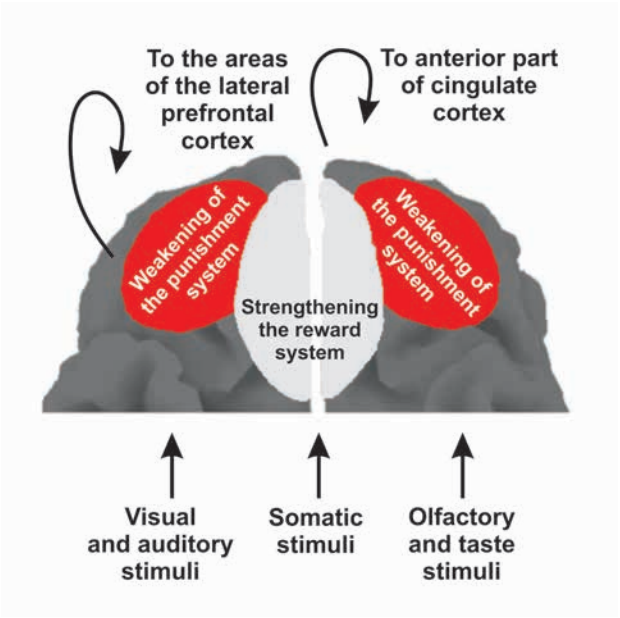


*Figure 13.* The reward / punishment system.
S o u r c e: Pąchalska et al., 2014 (modified)

**Individual, Social and Cultural Conditions of Creativity**

Many years of scientific research has allowed us to conclude that creative abilities are conditioned both in the norm and in pathology by the self system. The conscious Self creates an image of itself and the world in connection with its organism and the socio-cultural arena, especially with its own social group. The organism ensures survival and development, and the socio-cultural arena provides norms and rules of social life as well as cultural values and patterns. In this discourse between various types of an individual, social and cultural self, a unique interpreter of the world is created for each person and for only them (see Gazzaniga, 2011). Its creation constitutes the action of related factors (see *Figure 14*), which include:

1) *the brains and its codes*, i. e., undisturbed electric and chemical code (neuronal connections and neurotransmitters);
2) *the individual mind and its codes*, i. e., mono-specific, poly-specific, hierarchical and creative codes, developing on the basis of cognitive processes (including language and non-language communication) and emotional processes. This ensures metacognition, self-esteem and self-regulation;
3) *the social mind and its codes*, i. e., norms and rules of social life ensuring conflict-free functioning and integration with society;
4) *the cultural mind and its codes*, i. e., recognized as its own moral systems created by nesting in the socio-cultural environment, as well as its own system of values and cultural signs and symbols.

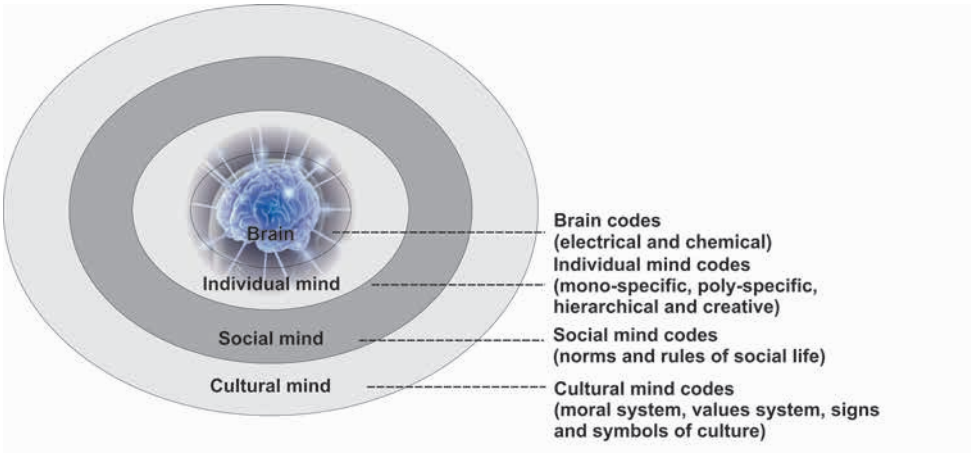


*Figure 14.* Hierarchy of brain, individual, social and cultural mind codes.
S o u r c e: Pąchalska, 2019

It should be emphasized that individual, social and cultural conditions of creativity are mainly associated with the three basic self-subsystems, that is:

1. *Awareness* that involves asking yourself about our identity: Who am I? In terms of civil law, this means sex, place of birth, origin, occupation, etc. This basic level of consciousness is often disturbed in the event of brain damage.
2. *Self-awareness*, i. e., awareness of myself and the state of my own mind, which is mainly associated with the questions: What am I? And how do other people see me? Answering these questions requires developed introspective skills, i. e., insight into yourself. It is also strongly associated with personality. In the cultural aspect, the way others see us is of particular importance, because this fact significantly affects our self-esteem. This process reflects the popular saying that "other people are our mirror".
3. *Meta-consciousness*, involving the questions: What values do I recognize? What is my place in the world? The answer to the question about recognized values determines our perception of ourselves, the world and our behavior. In turn, the answer to the question about our place in the world has a social and cultural aspect.

Recognized values are strongly embedded in culture and next to other cultural factors influence the shaping of our meta-consciousness. However, they can constitute a kind of self-limitation, which is manifested by various types of fundamentalism. This means that our meta-consciousness is also influenced by cultural conditions, among which should be mentioned a generational and procreative family, a group of friends, belonging to a social group, nationality, regionalism (cf. Bednarek, 2016), professed religion, etc. It should be emphasized that meta-consciousness is closely related to the development of the language system, called by Basil Bernstein (1990) the developed code. In Polish, the developed code concept corresponds to the term literary language (Kaczmarek, 2012).

## Discussion

A person with brain damage may experience either underdevelopment, destabilization or loss of both self and loss of one or more of the brain codes discussed above, with particular emphasis on the individual, social and cultural mind (cf. Pąchalska, Kaczmarek, & Kropotov, 2020). This changes the creative abilities of this person in a way that is difficult to predict, related to the brain damage itself (Abraham, 2018), as well as its consequences and undertaken rehabilitation interventions (Pąchalska, 2019). She may lose her abilities or already find a new way of expressing herself in creation. Her creation, if it is created at all, can be assessed on a multi-dimensional basis as a work of varying degrees of revealing or not, new and original or not, useful or not, beautiful or not, communicative or not, colorful or not, disturbed (rotations, perseverations, side skipping) or not, embedded in culture or not. Many scholars propose different ways of assessing this work, which is discussed in more detail in the monographs by Pąchalska, Bednarek, et al. (2020).

In this context, it should be emphasized that the Lurian approach, which is successfully developed in process neuropsychology (Pąchalska et al., 2014; Pąchalska, Kaczmarek, & Kropotov, 2020) makes it possible to understand that the essence of the discovery is its "reading" by the discoverer. After the act initiating the discovery, it may be given in the form of further attempts to improve and direct it to a specific purpose.

After the act initiating the discovery, it may be given in the form of further attempts to improve and direct it to a specific purpose, often designated by the artist's individuality (see Pąchalska, 2019). It is not difficult to prove that the self system exerts an influence on the creative act, because the quality of creativity is associated with both neurobiological processes (Abraham, 2018), as well as cognitive, emotional and executive processes, as well as with the broadly understood social and cultural background (Pąchalska, 2019).

## Conclusions

From the clinical neuroscience perspective, it is particularly important to use the creative possibilities of people, especially artists, with various brain injuries in their rehabilitation. However, something that is also important for the artist, selected works, especially the most characteristic and significant ones, are also recognized by critics. It also happens that they become part of the world's cultural heritage, such as the works of my patient Krystyna Habura, produced after a stroke in the process of art therapy, which are in the collections of several galleries in the world (see Pąchalska, 1999, 2003; Piechowski-Jozwiak & Bogusslavsky, 2013; Pąchalska & Góral-Półrola, 2020). The data presented confirm the significance of Luria's approach in the development of the neuropsychology of creativity. As it was also presented by his daughter (Luria E., 1991) the heritage of Luria's neuropsychological thought is significant and everlasting. To quote Horace: "Exegi monumentum aere perennius" [He built a work more durable than bronze]. His

scientific thought has inspired and continues to inspire many scholars in the world. In addition, this paper confirms also the importance of Luria's approach in the development of the neuropsychology of creativity.

### Limitations of the study

The preset paper is limited to the description of one patient. And, therefore, some researchers might believe it risky to draw general conclusion. On the other hand, the careful and longitudinal observation of the patient and analysis of the problems encountered by him may give us an insight into brain mechanisms of the process in question (art creation in this case) as was so masterly performed by Luria.

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# Proposal for Development of Spatial Functions at Pre-school Age on the Basis of Neuropsychological Analysis of Graphic Activity

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# Развитие пространственных функций у школьников на основе нейропсихологического анализа графической деятельности

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Child neuropsychology should be considered as a branch of general neuropsychology. Goals and tasks of child neuropsychology depend on a general psychological approach to the development. According to historical and cultural approach, neuropsychology as a science is directed not only towards assessing difficulties and establishing a diagnosis, but also towards creating methods for overcoming developmental problems and preventing such problems. Cultural and historical conception of development allows to study each psychological age according to a predominant type of child's activity. In case of pre-school age, the predominant activity is a role-play. This activity is extremely useful for child's development, but not enough for preparation to school. Play activity is performed in groups by communicative and precise material means (toys, objects and symbols). Another kind of useful activity is creative drawing as activity performed at a perceptive level and achieved by perceptive means. **The aim** of the article is to propose a way for introduction and gradual development of spatial orientation at a perceptive level within the content of original program for drawing. Neuropsychological analysis of drawing activity allows to specify brain mechanisms of the functional system of the action of drawing. The content of the functional system of the drawing action is presented together with the stages for introduction and formation of this action. The authors discuss

the usefulness of graphic activity for the development of spatial orientation at a perceptive level. Graphic activity should be broadly used in pre-school institutions as a basic method for formation of spatial analysis and synthesis and prevention of learning disabilities at school.

***Keywords:*** *spatial orientation; graphic activity; preschool development; child neuropsychology; developmental neuropsychology; prevention of learning disabilities.*

Детская нейропсихология должна рассматриваться как раздел общей нейропсихологии. Цели и задачи детской нейропсихологии зависят от общепсихологического подхода к развитию ребенка. В соответствии с историко-культурологическим подходом нейропсихология как наука направлена не только на оценку трудностей и постановку диагноза, но и на создание методов преодоления проблем развития ребенка и предотвращения таких проблем. Культурно-историческая концепция развития позволяет изучать каждый психологический возраст в соответствии с преобладающим видом деятельности ребенка. В случае дошкольного возраста преобладающей деятельностью является игра. Это занятие чрезвычайно полезно для развития ребенка, но недостаточно для подготовки к школе. Игровая деятельность осуществляется в группах с помощью коммуникативных и конкретных материальных средств (игрушки, предметы и символы). Другим видом полезной деятельности является творческий рисунок. Это деятельность, осуществляемая на уровне восприятия и достигаемая средствами восприятия. Цель статьи — показать способ внедрения и постепенного развития пространственной ориентации на уровне восприятия в рамках содержания оригинальной программы для рисования. Нейропсихологический анализ изобразительной деятельности позволяет уточнить мозговые механизмы функциональной системы выполнения рисунка, а также этапы формирования изобразительной деятельности. Авторы обсуждают полезность графической деятельности для развития пространственной ориентации на уровне восприятия. Графическая деятельность должна широко использоваться в дошкольных учреждениях в качестве основного метода формирования пространственного анализа, синтеза и предотвращения нарушений при дальнейшем обучении в школе.

***Ключевые слова****: пространственная ориентация; графическая деятельность; дошкольное развитие; детская нейропсихология; нейропсихология развития; профилактика нарушений обучаемости.*

## Introduction

Neuropsychology is a branch of psychological science directed to identification and study of relation between psychological processes and their brain organization. Child neuropsychology offers a perspective of analysis of such relation in different periods of ontogenetic development. According to historical and cultural approach in neuropsychology, relation between psychological processes and brain organization differs according to child's predominant activity of each ontogenetic period. According to our opinion, neuropsychology should take into account diversity of cultural activities which are typical and useful for dif-

ferent periods of ontogenetic development. These cultural activities conform the basis for consolidation of functional systems with broad amount of functional brain mechanisms. Each brain mechanisms should be included into meaningful actions within the process of collaboration an interaction guided by an adult.

Pre-school age is one of the specific ontogenetic periods, which possesses its own structure and content (Vigotsky, 1996). New psychological qualitative formations appear at the end of this period as new achievements of the age. Between them it's possible to mention such formations as voluntary activity, reflection, usage of signs and symbols, imagination and learning motivation (Salmina, 1988, 2013a; Davidov, 2000; Obukhova, 2006).

Vigotsky (2001) claimed that pre-school age is a sensitive period for acquisition of child's personality. This means that specific kinds of interaction between adult and child in groups of children should be organized during this period. Vigotsky, in his times, organized circles for reading, dramatization and performance for pre-school and school-children. Communication with art is one of significant cultural experiences and conform the basis for further development of children (Vigotsky, 2001).

Communication with artistic means and expression might be accessible starting from the basic stage of preschool development. This stage starts at the age of three years old, as at this period children acquirer elementary language abilities, possibility to use toys, objects and simple substitutes of objects. Complex play activity includes in its own content actions of verbal and non-verbal communication, usage of toys and objects and further substitution of objects and actions by representative symbolic means (Salmina, 1988; Brėdikytė, 2012; Solovieva & Quintanar, 2013a). Complex forms of play with roles and rules was described as rector activity of pre-school age (Elkonin, 1989, 2016). Play activity serves as a platform for the development of voluntary activity and gradual formation of symbolic function (Solovieva, Gonzáles, & Quintanar, 2016; Solovieva & Gonzáles, 2016). Verbal development together with enrichment of variety of broad circle of communicative non-verbal and representative means emerge during child's participation in collective plays (Solovieva, López, & Quintanar, 2015). Organization of dialogues in groups of children during plays helps for acquisition of regulative function of speech on external level as an important stage before passing on the level of inner speech (Vigotsky, 1995a; Escotto, 2011; Solovieva et al., 2015). As many psychological studies point out, the play is a powerful mean for development of imagination and self-regulation in pre-school children (Brėdikytė & Hakkarainen, 2017).

All these data clearly show the usefulness of new creative proposals for work with plays and game in pre-school institutions as a basic method for psychological development of activity and personality of children. At the same time, these methods serve also as the methods for prevention and correction of learning disabilities (Glozman, 2009; Soboleva, 2014a, 2014b, 2014c).

Nevertheless, neuropsychological analysis of learning disabilities at school age shows that play activity is not enough to guarantee positive functional development of brain mechanisms, which take part in the process of writing and reading. One of advantages of neuropsychological approach according to the theory of the structure and content of psychological actions is the possibility of analysis of brain mechanisms, which take part

in each action at different levels. Luria (1998) gave example of neuropsychological analysis of writing as a functional system. In this publication, Luria wrote that the action of writing presents different levels of functioning at different period of learning at school. Writing at the beginning and at the end of primary school is different processes with different functional system. His followers continued the same line and studied with precision different mechanisms of this functional system (Akhutina & Inshakova, 2008; Glozman, 2009).

It's important to stress that this point hasn't been perfectly understood and used in modern neuropsychology. The tendency to establish static and permanent localization of psychological functions in brain structures is still predominant in literature. This tendency reflects the aspiration to localize difficulties in school learning in same brain zones in all periods of school learning and to give same labels to pupils' difficulties with such terms as dyslexia and dysgraphia at all stages of school learning (DSM-5, American Psychiatric Association, 2014). According to Luria's conception of dynamic and systemic localization of superior psychological functions, the concepts of dyslexia and dysgraphia would at least not be same phenomenon in different periods of school learning.

According to Luria's conceptions, children might present difficulties in writing and reading due to broad variety of reasons. Between these reasons we may stress absence of functional preparation for school learning and also inappropriate methods of introduction of written language at school. Dependence of successful writing at school on organization of the process of learning and interaction between teacher and pupils in the third grade of primary school was studied in some previous publications (Solovieva, Torrado, & Quintanar, 2018, 2019).

The goal of our study is to present neuropsychological analysis of graphic activity as the basis for design of effective methods for development of spatial analysis and synthesis as prevention and correction of developmental difficulties. The article is of methodological nature and presents qualitative results of the work with original method for gradual formation of drawing by stages (Solovieva & Quintanar, 2016a). The article presents examples of qualitative experience of application of this method to pre-school children in private kinder garden in Mexico, organized and supervised by the authors of the article.

## Functional System of Graphic Activity

Readiness for school might be studied according to psychological, socio-pedagogical aspects and neuropsychological aspects (Soboleva, 2014a). Psychological aspects refer to child's interest and motivation for learning, while socio-pedagogical aspects refer to adult's strategies and communication with the child. Neuropsychological aspects include functional readiness of essential elements of functional systems for reading and writing. Neuropsychological analysis of the structure and content of different kind of psychological actions may help for understanding of useful methods for development and prevention of learning disabilities at pre-school age. As a concrete example of such analysis we shall present analysis of functional system of writing as a kind of graphic activity.

Both drawing and writing might be represented as two kinds of graphic activity. Vigotsky (1995b) has described children's drawing as previous history of writing. By his own part, Luria (1998) has always presented writing process as a clear example of complex functional system, which includes different functional components supported by various brain cortical zones. Such functional system doesn't exist in the brain at the beginning of development, but might be conformed according to participation of the subject in cultural activity. Considering importance of Luria analysis of functional system of writing, it's necessary to mention that broad participation of subcortical mechanisms takes part in graphic activity, when started from pre-school age.

We propose to consider drawing and writing processes as two types of graphic activity; this makes it possible to compare functional systems of both processes. Graphic activity includes the following essential aspects or functional operations:

- direction to previously established goal or anticipated image of graphic production with constant verification of the process and accordance with the model;
- organized sequential and precise hand movements with the usage of external mean (pen or pencil);
- spatial organization of lines on perceptive level.

The mentioned aspects or functional operations require a plenty of brain functional mechanisms at cortical and subcortical levels (see *Table 1*).

In case of writing, it's necessary to add operations or reflective actions of phonemic analysis of oral speech of each language in order to transform oral words into graphic representation. Functional system of writing is more complex in comparison with functional system of drawing, since it requires less quantity of functional elements. The *Table 1* shows functional systems of drawing, while *Table 2* show functional system of writing. According to activity theory, operations are automatic and semiconscious processes, while the actions are always directed to conscious goals of the subject. On different level of formation of each activity, both actions and operations might be accomplished by a subject. Initially, the subject starts acquisition of activity with conscious actions, which require complete functional system for each action. Later on, according to practice and the process of interiorization, actions pass to the level of automatized operations and the functional system reduces.

*Table 1*

**Functional system of graphic activity: drawing**

| Actions / operations | Neuropsychological mechanisms |
|---|---|
| Direction/verification of the established goal with observation or imagination of a model for drawing | Programming and control (possible visual perception) and spatial functions holistic |
| Organized hand movements with the usage of external means | Spatial global perception<br>Spatial analytic perception<br>Motor kinetic organization |

*Table 1 (continued)*

| Actions / operations | Neuropsychological mechanisms |
|---|---|
| Organization of image on perceptive Space | Motor kinestetic integration<br>Spatial global perception<br>Spatial analytic perception<br>General brain activation |

According to *Table 1*, spatial analysis and synthesis is one of essential functional elements of graphic activity, both of drawing and writing. The *Table 2* presents the content of the functional system of graphic activity for the case of independent writing.

*Table 2*

**Functional system of graphic activity: independent writing**

| Actions / operations | Neuropsychological mechanisms |
|---|---|
| Direction/verification of established idea/ goal of writing production | Programming and control of the goal of writing |
| Codification/decodificaiton of system of sounds of language into system of graphic representation | Phonematic integration<br>Kinestetic integration<br>Audio-verbal retention |
| Organized hand movements with the usage of external mean | Spatial global perception<br>Spatial analytic perception<br>Motor kinetic organization |
| Organization of image on perceptive space | Motor kinestetic integration<br>Spatial global perception<br>Spatial analytic perception |
| Organization of grammar, morphology, lexicon, semantic | General brain activation<br>Programming and control<br>Spatial analysis<br>Motor kinetic organization |

The *Table 2* gives an approximate idea of complexity of functional system of the writing process. The aim of the article doesn't make it possible to discuss all mechanisms of writing process, because their participation depends on the level of grammar, morphological, lexical and meaning variety of written production and of personal goals of each subject of writing activity (Luria, 1998; Akhutina, 2002). Neuropsychological studies evidenced that difficulties in writing process might depend on poor level of functioning of spatial functions (Akhutina & Zolotariova, 2007; Solovieva & Quintanar, 2016b). According to literature, these functions include global strategy of perception of representations as unique images related mostly to right hemisphere and analytic strategy of perception of details and coordinates orientation related mostly to left hemisphere (Springer & Deutsch, 1981). Different studies have detected impropriate development

of concrete visual images at the end of pre-school age (Akhutina & Pilayeva, 2003; Veraksa N. E. & Veraksa A. N., 2012). Low level of development of spatial perception conduct to spatial confusion of letters, mathematic signs and digits at school. Problems with spatial orientation may become a cause of difficulties in written production and understanding of texts together with impossibility to interiorize structure of number and to solve properly mathematic problems (Akhutina & Zolotariova, 2007). It is possible to say that functional deficit of spatial analysis and synthesis is one of neuropsychological reasons of diagnosis of dyslexia, dysgraphia and dyscalculia at school age (Akhutina & Zolotariova, 2007; Akhutina & Inshakova, 2008; Akhutina & Pilayeva, 2012).

During the period of pre-school development, starting with the age of three years, it's rather difficult to separate these two strategies, so that both hemispheres work for both strategies of perceptive analysis and synthesis. That's why proper development of spatial functions and process of orientation at a perceptive level is one of central necessities of pre-school age.

## Description of Proposal for Introduction of Graphic Activity

In order to guarantee successful development of spatial functions, they should be included in specific cultural actions of children. At the same time, these specific actions should not only be accessible for little children, but also should contribute to their psychological development. Constant repetition, work by unreflective simple reinforcement, adaptation or mechanic memorization are not the best actions to guarantee reflexive perception, thinking and creativity in pre-school children (Poddyakov, 2013). The actions chosen for work should correspond to the necessities of psychological age of children.

According to psychological content of pre-school age, drawing action results as the best choice for introduction of graphic activity. Specific features of pre-school age consist in predominant line of communicative and affective participation of a child in joint activity (Elkonin, 1989, 2016; Vigotsky, 1996). *Table 3* resumes psychological feature of preschool age according to essential new formations of this ontogenetic period as indicators of positive preparation to school (Salmina, 2013b). In the present article, these psychological features are taken in consideration only in relation to importance for development of graphic activity. The authors are conscious that a lot of other important goals of development should be achieved in other kinds of pre-school activities such as play, artistic, physic and communicative activities (Bruce, Hakarainen, & Brėdikytė, 2017; Veraksa N. & Sheridan, 2018).

The *Table 3* shows psychological features of pre-school age according to the concept of psychological age, including psychological new formations and content of significant actions.

According to *Table 3*, introduction of graphic activity at pre-school age should be based on the necessity of visual perception and analysis of concrete objects and images. At this age, children have to operate with enriched media of images and objects with a big variety of changeable and dynamic features such as shapes, colours, textures, details, spa-

tial position of elements and shapes and so on. At the same time, these objects have to be functional cultural objects and not symbols and signs. The children have to recognise and use in their practical actions different cultural objects before they start to use and to create cultural symbols by themselves. Adults should guarantee emotional and affective positive involvement of children into practical and creative actions with objects and toys (Veraksa N.E. & Veraksa A.N., 2012). Impossibility for differentiation of concrete objects and symbols may appear as one of the obstacles for development of complex symbolic functions and of understanding of the meaning of symbols at school age, which conduct to learning disabilities and problems in adaptation to school (Solovieva & Quintanar, 2012a; Salmina, 2013b). All these considerations represent a solid base for proposal of specific method for introduction of drawing as the first type of graphic directed activity in child's life.

*Table 3*
**Psychological feature of pre-school age**

| New psychological formations | Content of useful actions |
|---|---|
| Voluntary activity | Present precise goals of each perceptive task with explanation and orientation |
| Imagination | Constant presentation of diversity of curiosity-provoking perceptive models with explanation and orientation, interesting and attractive models and tasks |
| Symbolic function | Suggestions for multiple substitutions and representations with examples and orientation |
| Reflection | Verbal comments and proposals for modification of tasks and means during participation in tasks in groups, emotional involvement in all tasks |

The drawing should start with observations and operations of concrete images and objects instead of drawing of schemes, geometric figures or symbols, which represent no sense for little children.

We propose to start the work of introduction of graphic activity by drawing at the age of three year in groups in pre-school institutions. Our proposal is based on qualitative psychological and pedagogical experiment of introduction of graphic activity in small groups of children from the age of three years. We may call our proposal also as a variant of formative experiment in Vigotsky's and Gaperin's tradition, when the process of innovation of developmental practice consists in introduction and gradual formation of actions, which are absent in previous experience of participants (Galperin, 2002). The whole process implies elaboration of orientation base of action for specific action, which would conduct to formation of drawing activity. In order to identify such initial action for children it's necessary to analyse psychological operative and functional content of graphic activity. Operative content of activity helps to analyse the whole process, which has to be fulfilled by each participant of drawing activity. This content includes the following operations (based on Solovieva & Quintanar, 2019a):

1. Election of the object (external or internal model), which will be drawn.
2. Organization of the space on paper (surface) for representation of the shape of elected model.
3. Organization of the space on paper (surface) for representation of elements of elected model.
4. Determination of the general predominate shape of the object.
5. Election and disposition of the details of the objects.
6. Representation of the shape of object with the help of external shape.
7. Representation of specific details of the object.
8. Verification of the whole execution, comparison with the model, detection of errors, correction of errors.

According to Leontiev's conception of psychological activity, each action is directed to previously established goal. Later on, action might be reduced, automatized and converted into operation without necessity of reflective fulfilment (Leontiev, 1975, 1983). We use this methodological principal for our proposal of formation of graphic activity. At the very beginning, all mentioned operations represent independent actions of participants with conscious goal. The children require specific operative external help, including emotional support and orientation base of action. Additionally, children have to work firstly at level of material action, using attractive objects and toys.

Drawing activity, as we have previously mentioned, starts with establishment of the goal for drawing and continues with representation of organised lines properly organized on perceptive space (perceptive plan or level). The whole action of drawing is perceptive action, while children of three years old usually fulfil only concrete actions with objects and toys. Little children have strong difficulties for establishment of such a goal as they usually name their drawing after they produce some lines without specific shape and without differential features. Such first graphic productions aren't recognisable for children, their parents or teachers. Instead of waiting for "normal" and "natural" development of drawing and observe how later it will convert into writing and describe this "normal" process as followers of constructivism do, we prefer work with specific introduction of drawing by stages as follower of Galperin's conception of orientation (Galperin, 1998). According to this conception, orientation is the central object of psychological study, according to which success of activity depends on proper orientation. In case of pre-school children such orientation should be provided by adults.

In case of introduction of drawing activity, the specialist has to start on the level of actions with objects and toy and later pass to the level of creation of perceptive images in perceptive space. Such passing will be significant for development of child's spatial functions if conscious reflection of spatial features of images and their disposition on space would be included in this process. The model for reflective perception and analysis should be included at the first stage. Different stages and methodological considerations for orientation must be included into this process.

## Stages of Introduction of Graphic Activity

Our proposal finds strong arguments in the following theoretical and methodological psychological conceptions and of research data:

1. Relevant significance of spatial functions for cultural development, their relation to cognition, verbal and mathematic abilities (Luria, 1998).
2. Necessity of specific development of spatial functions in pre-school age (Akhutina & Pilayeva, 2003) as prevention of learning disabilities.
3. Success in experimental groups and positive usage of formative experiment with graphic activity for developmental of spatial functions (Solovieva & Quintanar, 2016c).
4. Cultural-historic paradigm of psychological development, which consider meaningful interaction between adult and child (Vigotsky, 1995a; Leontiev, 2000).
5. Theory of step-by-step formation of mental actions starting from external material level with possibility of passing to perceptive level of graphic actions (Galperin, 2000; Talizina, 2019).
6. Orientation base of action as the central element of content of new actions (Zaporozhets, 2000; Galperin, 2000; Solovieva, 2014).

The program includes four general stages (Solovieva & Quintanar, 2016a; 2019b):

1. Previous stage (preparation of drawing), which implies work with material objects and toys, identification and analyses of all perceptive features, comparison of objects by features, corporal and perceptive symbolic representation of actions.
2. Drawing of independent objects according to the shape and external model, which implies introduction of representation of objects based on observation of models (objects and concrete images), analysis of features, identification of basic shapes.
3. Drawing of objects with enriched features according to internal model, which includes analyses of features, representation of shapes and details of perceptive models.
4. Drawing of situations ("illustrations for fairy tales" or "landscapes") according to external or internal (imaginative) model, proposed and created by participants.

All actions were fulfilled in groups of children by constant verbal orientation of adult. The sessions were organized by teachers on the basis of emotional involvement of children in collective activity.

## Results and Discussion

The process of child's development depends on the organization and selection of activities, in which the child takes part during this period of development. Pre-school institutions frequently chose tasks and activities empirically without any justification from psychological point of view (Salmina, 2013a, 2013b; Obukhova, 2006).

Recently, the ways of design of the methods for prevention and correction of difficulties in future school learning has become one of new points of attention for developmental psychologists and neuropsychologists (Solovieva & Quintanar, 2016a, 2017a). Creation and introduction of new methods for psychological development might show new paths for early education. Our proposal consists in initial introduction of joint actions of drawing from the very beginning (Solovieva & Quintanar, 2016b).

The stages of our proposal for introduction and development of graphic activity at pre-school age are used in private Kinder Garden (Kepler College) in the city of Puebla, in Mexico. The whole work of this college is organized in the basis of activity theory applied to the process of education (Talizina, 2019). Pre-school development include participation in guided play activity (Solovieva & Quintanar, 2017b, 2019a, 2019b), work with understanding and interpretation of fairy tales and formation of graphic activity by stages. Formation of graphic activity take place in groups of pre-school children from three to six years old respectively in groups of first, second and third level of pre-school education. The number of children varies from 4 to 10 participants in groups each year.

Results of progress in graphic activity are qualitatively different at each level of pre-school development. At the first year of pre-school development it's possible to achieve simple representation of global shape of concrete objects by children. At the second grade of pre-school education the children may introduce specific details into their representations. During the third year of work, children start to propose and create their own imaginative models of complex situations according to the content of tales and stories, according to examples of landscapes and external models for picturesque situations. The following examples show achievements of the children in diverse groups each year of pre-school education.

Examples of drawing produced by pre-school children from three to six years old are presented below. All children were pupils of Kepler College of 1st, 2nd and 3rd grades of preschool educational. Children worked with the program every day for one session of 50 minutes approximately.

On the first stage children from the first grade of pre-school education worked with external shapes, representation of movement of objects by gestures and initial drawing of lines with sense. Natural phenomenon as raining and clouds helped children to imagine lines with sense and represent them properly on the paper. Example 1 shows the task completed by a child of three years old. An adult prepared the "clouds" and the child continued with the "rain" (all photographs are courtesy of Kepler College).

Example 1. Representation of vertical lines. "Raining" (see *Figure 1*).

On the second stage children from the second grade of pre-school education managed to produce simple concrete objects by using curve lines and points. External material or perceptive models were always used on this stage. The teacher oriented the children with oral speech and explanation of all details of each object (example 2).

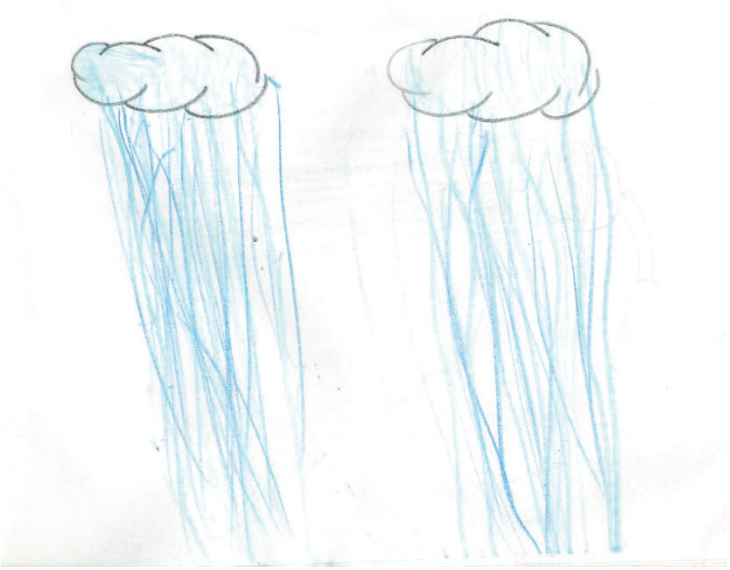

*Figure 1.* "Raining". Clouds are drawn by teacher and the child only adds the lines for "raining"

Example 2 shows the drawing of a child from the second grade — drawing of elephant by model[1] (see *Figure 2*).

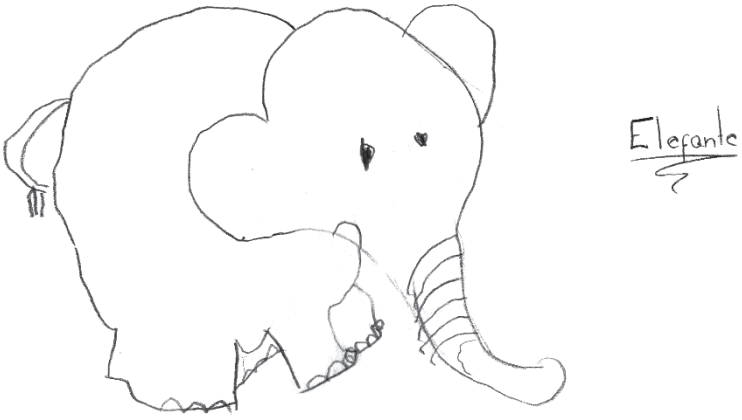


*Figure 2.* "An elephant"

On the third stage children from the third grade of pre-school education managed to produce complex objects by using curve lines and differential spatial relations. The context of fairy tales was frequently used in order to provide orientation and impulse imaginations of children. The teacher also tried to make own picture on board as an example for children. The teacher oriented children with oral speech and explanation of all details

[1] The teacher wrote the word "elephant" on the drawing of the child.

of each image. The children added own details and features to the drawings. Complex spatial relation appeared on this level (example 3).

Example 3 present lovely work if the child the third grade, who managed to draw this Little Siren under the water according to well-known tale by H. Ch. Andersen (see *Figure 3*).

*Figure 3.* "Little Siren under the water"

On the fourth stage children from the third grade (last three months) started to construct own examples of complex situations with spatial orientation of each element with the help of toys, objects, symbols and marks (town, village, zoo, forest and so no). Examples of illustration of landscapes and photographs were used as examples in order to provide orientation to this activity. The teacher took part in all propositions and constructions of situations. The children added differential details to the drawings of complex situations. Complex spatial relation showed pronounced development at this stage (example 4).

Example 4 shows complex drawing of the child from the third grade who managed to present the street with symbolic means for direction of the traffic (see *Figure 4*).

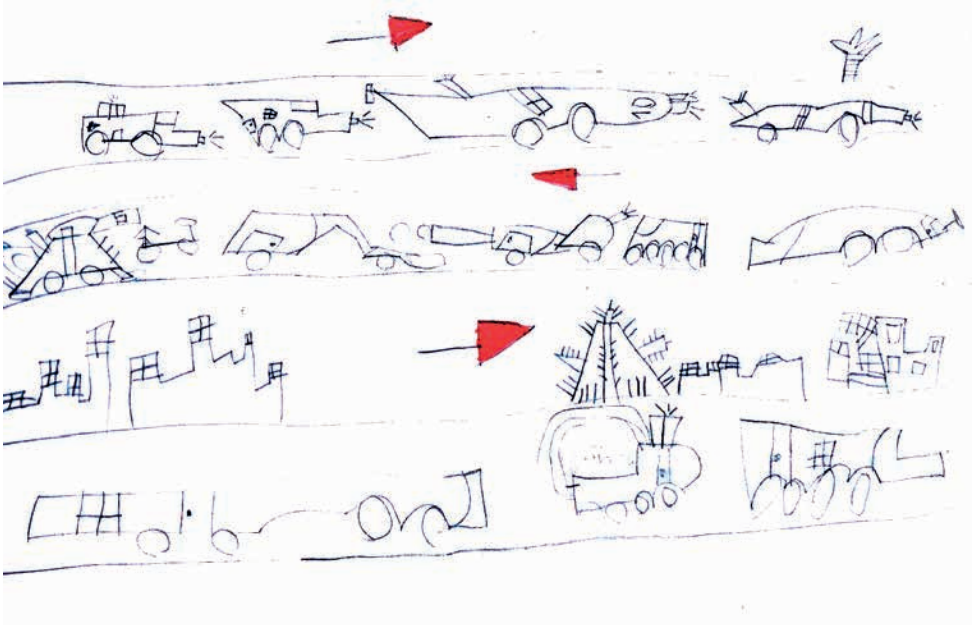

*Figure 4.* "Traffic in the streets of the town"

These examples show the progress in children's ability to represent models on perceptive space. Such tasks include both aspects of global and analytic perception, which involve both brain hemispheres according to neuropsychological research (Springer & Deutsch, 1981). Neuropsychological assessment of spatial functions commonly uses drawing tests. These tests might represent abstract models or concrete models (Luria, 1973; Akhutina & Pilayeva, 2012; Solovieva & Quintanar, 2017). Such tests detect serious difficulties of holistic and analytic strategies in children with learning disabilities and adults with brain damage. Difficulties might be found in production of independent drawing by instruction and in tasks for copy of different objects by young children with low level of development of spatial functions (Glozman, 2009; Akhutina & Pilayeva, 2012; Soboleva, 2014b; Solovieva & Quintanar, 2016c).

Different kind of mistakes are related to functional deficit of left and right hemisphere. Adult patients with posterior brain lesions also show specific difficulties in holistic (related to dysfunction of right hemisphere), analytic perception (related to dysfunction of left hemisphere) or both strategies of perception (both hemispheres).

According to the data of difficulties of adults with posterior brain damage, detected specifically in drawing tasks and similar difficulties in little children who aren't able to follow tasks of graphic activity, it's logic to suppose that guided introduction and formation of graphic activity by levels might help both processes of development in children and rehabilitation in adults and adolescents (Solovieva & Quintanar, 2017b, 2018a, 2018b). Our results show positive effect of development of drawing activity in children (Solovieva & Quintanar, 2017b). Some previous original research permits to conclude that work with

drawing is useful method for neuropsychological rehabilitation of adults and adolescents with posterior brain damage.

One of our studies showed how drawing tasks helped for rehabilitation of spatial analysis and synthesis in adult patient with semantic aphasia (Solovieva & Quintanar, 2018b). The patient was systematically trained to use own reflection for analysis of relation between details in objects and representations. This work shows how the tasks with established goals for drawing activity help to re-establish spatial functions of analytic perception. Another study shows how drawing tasks helped for re-establishment of global perception in a left-handed patient with brain damage in left hemisphere (Solovieva & Quintanar, 2018c). In this case, reflection of the patient was directed to production of global shaped of objects and symbols by stages. Same tasks directed to reflective identification of shapes and spatial representation of details in representations helped in case of rehabilitation of adult with brain damage by stoke in right hemisphere (Solovieva, López-Cortés, & Rosas-Alvares, 2018).

These examples illustrate that spatial functions might be introduced, development and re-established by presentation of specific guided orientation with conscious goals of analysis and synthesis of representation. Graphic conscious activity represents ideal context for establishment of such goals for children and adults.

The stages of work with graphic activity show the usefulness of orientation for development of spatial functions (Solovieva & Quintanar, 2017b). These stages help to create orientation for realization of the actions of representation by gestures and concrete actions as the basis for later orientation on the level of graphic space. Production of lines and global shapes is the start point of drawing activity. Later on, children became able to produce objects with plenty of specific features. At the final stage, individual imaginative models became accessible for children.

We believe that our work with introduction of graphic activity has stretch relation with the way how Luria understood the process of children's development at pre-school age. His own research of this topic directed to formation of creative construction tasks in groups of pre-school children determined that specific orientation and quality of materials for construction lead to better orientation in presented models. Children who were allowed to use complex elements and shapes with guided orientation showed better results in final tests for constructive activity (Luria, 2013). Our study is of the same spirit of great possibility and effectiveness of proper cultural development, which shows that spatial functions might be formed within graphic activity. Such functions don't appear "naturally" only according to maturation of brain cortical zones.

In "normal" conditions, the level of acquisition of graphic abilities is very low in Mexican pre-scholars together with low level of symbolic development (Solovieva & Quintanar, 2013a). Low level of graphic activity corresponds to low level of spatial functions and possible learning disabilities, especially in acquisition of writing and reading (Solovieva & Quintanar, 2016c).

According to historical and cultural conception of psychological development and activity theory, it's possible to introduce and to guide the children in their activities. In our research, we propose to start formation of graphic activity on material level of concrete

objects, so that the child may identify consciously all features of the objects. The shape is introduced as one of the feature, that is essential for drawing process. The introduction of graphic activity starts by representation of shapes and movements by gestures, actions with objects and identification of external shapes of objects by usage of models of shapes (Solovieva & Quintanar, 2012b, 2013b, 2016b). Later, perceptive work starts, which has a positive effect of development of spatial functions. Perception and production of lines and shapes is initial stage of graphic representation. Materialized orientation is presented all the time on order to facilitate identification of shapes in real and perceptive objects (Salmina & Glebova, 2005a, 2005b; Salmina, 2009). Before the program all children have shown absence of developed drawing activity. After program application, all children showed qualitative positive achievements in graphic activity such as spatial global and analytic orientation, essential features and shapes of represented objects.

The election of the content of the tasks used during introduction of graphic activity points out the necessity of precise actions of the child. Such actions might be detected on the basis of analysis of functional system of graphic activity at different levels: level of drawing of objects and level of writing. Each level has to be introduced and formed as guided activity of the child by an adult or of the patient by neuropsychologist.

The present article described effective procedures for introduction and development of spatial functions within the context of graphic activity. Future studies might show the possibility of the work with other components of functional system during development and rehabilitation. Neuropsychology, as a branch of psychology based on general activity theory should be directed to innovations in education and treatment of functional difficulties in children and adults.

## Conclusions

Analysis of the functional system of graphic activity allows to detect one of the central functional elements of this activity: spatial functions. Psychological analysis of the content of this activity permits to identify initial action of representation as the first stage for introduction of this activity. The article has presented the stages and procedure of formation of graphic activity in groups of pre-school children. The way for formation and rehabilitation of spatial functions within meaningful cultural actions of drawing as original method for development and rehabilitation was presented.

The stages of the proposed method are the following: the stage of preparation for drawing on a material level; the stage of drawing of independent objects on the basis of materialized orientation and according to external material models; drawing of objects with enriched features according to perceptive and internal model and, finally, drawing of situations according to external or imaginative models.

Future research might be directed towards precise modification of the method for cases of developmental difficulties, learning disabilities in primary school and proposal of methodological adaptation for adults and adolescents with acquired brain injury.

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# An Impact of Biofeedback Training on the Effectiveness of Cognitive Training in Stroke Patients

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# Влияние БОС-тренинга на эффективность когнитивных тренировок у пациентов с инсультом

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**Introduction.** The clinical significance of cognitive impairments remaining in patients with acute cerebrovascular accidents (stroke) in the second rehabilitation period actualizes the need for their correction. The technique of cognitive training shows a high degree of cognitive function recovery, but negative emotional states that may occur in patients during rehabilitation may reduce its positive effect. In this regard, the use of biofeedback (BFB) training to stabilize the patients' psycho-emotional state before cognitive training can increase its effectiveness.

**Purpose.** To evaluate the impact of BFB-training on the effectiveness of cognitive training in patients with acute cerebrovascular disorders in the second rehabilitation period.

**Design.** 41 post-stroke patients (ischemic stroke) in their late recovery period with varying degrees of cognitive impairments, not reaching the level of dementia, completed a course of standard rehabilitation and psychological treatment, including cognitive training sessions. Of these, 20 patients (the experimental group), before cognitive training, addition-

ally underwent a BFB-training based on the skin conductance parameter. Psychodiagnostic evaluation conducted before and after the rehabilitation course included a study of visual and auditory-speech memory, volume, distribution, and attention switching, the level of depression, as well as unconscious and conscious anxiety.

**Results.** After the course of rehabilitation and psychological treatment, the experimental group showed a statistically significant improvement in all cognitive functions and indicators of psycho-emotional state. Positive dynamics in the control group is observed only in the cognitive sphere. The level of cognitive functions in the experimental group after the rehabilitation course was significantly higher than in the control one.

**Conclusions.** An additional inclusion of BFB-training in the course of rehabilitation and psychological treatment helps to increase the effectiveness of cognitive training by stabilizing the psycho-emotional state, as well as by providing a positive impact of biofeedback methods on cognitive functions.

***Keywords:*** *post-stroke patients; cognitive function impairments; cognitive training; biofeedback.*

**Введение**. Клиническая значимость сохраняющихся когнитивных нарушений у пациентов с острым нарушением мозгового кровообращения во втором реабилитационном периоде актуализирует необходимость их коррекции. Метод когнитивных тренировок показывает высокую степень восстановления когнитивных функций, однако негативные эмоциональные состояния, которые иногда возникают у пациентов в процессе реабилитации, могут снижать его положительное влияние. Использование БОС-тренинга для стабилизации психоэмоционального состояния перед когнитивными тренировками может повысить их эффективность.

**Цель.** Оценить влияние БОС-тренинга на эффективность когнитивных тренировок у пациентов с острым нарушением мозгового кровообращения во втором реабилитационном периоде.

**Дизайн.** 41 пациент с ишемическим инсультом в позднем восстановительном периоде с разной степенью когнитивного снижения, не достигающего уровня деменции, прошел курс стандартных реабилитационно-психологических мероприятий, содержащий когнитивные тренировки. Из них 20 пациентов (экспериментальная группа) дополнительно перед тренировками проходили БОС-тренинг по параметру электрической кожной проводимости. Психодиагностическая оценка, проводимая до и после курса реабилитации, включала исследование зрительной и слухоречевой памяти, объема, распределения и переключения внимания, уровня депрессии, а также неосознаваемой и осознаваемой тревоги.

**Результаты.** После курса реабилитационно-психологических мероприятий в экспериментальной группе отмечено статистически значимое улучшение всех когнитивных функций и показателей психоэмоционального состояния. Положительная динамика в контрольной группе наблюдалась только в когнитивной сфере. Уровень когнитивных функций в экспериментальной группе после курса реабилитации был достоверно выше, чем в контрольной.

**Выводы.** Дополнительное включение БОС-тренинга в курс реабилитационно-психологических мероприятий способствует повышению эффективности когнитивных тренировок за счет стабилизации психоэмоционального состояния, а также положительного влияния методов биоуправления на когнитивные функции.

***Ключевые слова:*** *пациенты с острым нарушением мозгового кровообращения; снижение когнитивных функций; когнитивные тренировки; биологическая обратная связь.*

## Introduction

A high prevalence of cognitive impairment after stroke determines the relevance of research in this area. It is cognitive impairments that mainly result in a deterioration of post-stroke patients' recovery prognosis, exacerbating the risk of recurrent stroke, and a significant decrease in their quality of life (Prokopenko, Mozhejko, & Koryagina, 2014). It is known that active recovery of cognitive functions occurs within the first six months after a stroke and most of the scientific studies regard this period of recovery (Ostankova & Habarova, 2016; Naumenko, Gromova, & Preobrazhenskaya, 2017; Guzeva V. I. et al., 2018). However, in the late recovery period, according to the literature, from 11 to 31 % of the remaining cognitive impairments are observed (Guzeva V. I. et al., 2018; Levin, Usol'ceva, & Yunishchenko, 2007), so a decrease in interest in this period must be viewed unjustified.

A high significance of restoring cognitive functions and difficulties emerging during this process give rise to a reasonable question about how to correct them. One of the most actively developing areas today is a cognitive training technique and its positive impact has been confirmed in numerous studies (Prokopenko et al., 2014; Prokopenko et al., 2017; Gamito et al., 2017; Jaeggi, Karbach, & Strobach, 2017; Zlobina, Epaneshnikova, & Zinov'eva, 2018; Prokopenko, Bezdenezhnykh, Mozheyko, & Petrova, 2018). The appearance of a large number of computer programs for implementing this method indicates its availability and effectiveness (Prokopenko et al., 2014; Prokopenko et al., 2017; Gamito et al., 2017). At the same time, in recent years the problem of improving the outcomes of cognitive training has attracted researchers' attention as well. In particular, it has been found that applying transcranial electrical stimulation enhances working memory training (Richmond, Wolk, Chein, & Olson, 2014; Wang et al., 2019).

It is known that the process of post-stroke recovery is a quite complex and lengthy one, therefore, patients may experience various types of adverse emotional states (Ermakova, 2018). A lack of rapid success generates depressive reactions, an inability to perform ordinary actions creates a feeling of frustration, changes in their somatic state lead to an increased feeling of anxiety, etc. It is worth noting that these states may be situational in their essence and do not reach a clinical level of their manifestation, but their presence can have a negative impact on the effectiveness of the rehabilitation process in general and cognitive training in particular. For example, depressive symptoms have been found to reduce the effectiveness of cognitive training (Felix, Du, Taylor, & Rebok, 2019).

In our opinion, a method for correcting such dynamic negative emotional states could be a biofeedback training aimed at reducing post-stroke patients' emotional tension and improving their adaptive state (Dyomin & Poskotinova, 2014; Epaneshnikova & Kabataev, 2017). Therefore, additionally including the biofeedback training into the course of rehabilitation and psychological treatment can increase the effectiveness of cognitive training by stabilizing such patients' psycho-emotional state, as well as by having a positive impact of biofeedback techniques on cognitive functions (Sutarto, Wahab, & Zin, 2013; Trofimova, Kayutina, Isajchev, Chernorizov, & Varako, 2018; Marinina, 2019).

## Methods

### Participants

The study sample consisted of 41 people (25 men and 16 women) aged from 45 to 63 years (57.0±3.21) who had an acute cerebrovascular accident (onset of an ischemic stroke was six months or longer prior) and were in their second rehabilitation period (the late recovery stage). All the patients had cognitive impairments of varying degrees of severity, not reaching the state of dementia. All participants had the highest level of education. Participants gave their informed consent form for additional research procedures.

### Procedure

The experimental base was the Neurological Department of the Tomsk Research Institute of Balneology and Physiotherapy of the Federal Siberian Research Clinical Centre under the FMBA of Russia (Tomsk), where the study participants underwent a course of rehabilitation for 3 weeks (21 days), which, in addition to physiotherapy procedures, included cognitive training sessions. The choice of cognitive training programs was determined by the existing cognitive impairments in the patients and was aimed at restoring the visual memory and attention functions. The sessions were carried out daily (5 times a week) for 30 minutes by means of the CogniPlus software (CPS, SCHUHFRIED GmbH; the NBACK and SELECT (S3) programs).

### Testing

The psychodiagnostic instruments involved the following techniques: Learning 10 Words by A. R. Luria (for evaluating one's direct memorizing as well as short- and long-term memory) (Rubinshtejn, 1999); the Hospital Anxiety and Depression Scale (HADS) (to assess one's level of anxiety and depression) (Zigmond & Snaith, 1983); the NS-PsychoTest computer complex (Neurosoft Company, Russia): Memory for Numbers (to evaluate visual memory) (Balin, Gajda, & Gerbachevskij, 2000), the Schulte-Platonov Red-Black Tables (to assess attention volume, distribution and switching) (Shapar', Timchenko, & Shvydchenko, 2007), M. Lüscher's eight-color test (to evaluate one's unconscious anxiety) (Sobchik, 2001).

**Statistical Analyses**

Each of the patients was randomly assigned to either the experimental group ($n = 20$) or the control group ($n = 21$) based on simple randomization with random number generator. In experimental group ($n = 20$) in addition to cognitive training, underwent a biofeedback (BFB) training as well. The sessions were conducted using the Biofeedback 2000 x-pert software and hardware system (SCHUHFRIED GmbH; the JigsawPuzzle program) every day (5 times a week) for 15 minutes before cognitive training. The BFB-training was carried out based on the skin conductance parameter (SC) in parallel with registering the study participants' uncontrolled physiological indicators: the level of electrical skin resistance (ESR), hand temperature (HT), heart rate (HR). The choice of skin conductance as a parameter to be controlled is due to its relationship with conscious and unconscious emotional stimuli (Gordievskaya & Gordievskij, 2014; Christopoulos, Uy, & Yap, 2016).

Microsoft Excel (2010) and IBM SPSS Statistics v19 were used for statistical processing of the data collected. Testing the normality of the data distribution was performed applying the Shapiro-Wilks criterion. If there was a normal distribution of the parameter, the data were presented as a mean and a standard deviation ($M \pm SD$). If the distribution was different from normal, the data were presented as a median (*Mdn*) and an interquartile range in a format of *Mdn* [*Q1, Q2*], where *Q1* is the lower quartile and *Q2* is the upper quartile.

To determine significant differences in the paired samples (before and after psychological treatment) under the normal distribution law, the Student's paired t-test ($t; p$) was used. If the parameter distributions in the dependent samples being analyzed differed from the normal one, the Wilcoxon T-test ($Z; p$) was applied. If the parameter distribution in the two independent samples in question differed from the normal one, the non-parametric Mann–Whitney U-test ($U; Z; p$) was used. To compare the effectiveness of psychological treatment and rehabilitation, the variable *Es* was introduced, which was calculated as the ratio of the difference in the indicator values before and after psychological treatment to the indicator with a higher value (the comparison of variables was performed as that of independent series). To reveal the relationship between the indicators if differed from the normal distribution, the Spearman $r_s$-test ($r_s; p; n$) was used.

## Results

Before the beginning of the rehabilitation and psychological treatment concerned, no statistically significant differences in psychological indicators were found between the groups ($p > 0.05$). Patients in the control and experimental groups were characterized by a decrease in visual and auditory-speech memory, a low level of attention volume, distribution and switching. Indicators of their emotional sphere did not reach negative values; however, 10 % (2 patients) in each group were diagnosed with a subclinical level of anxiety and depression.

After the rehabilitation and psychological treatment in the control group, there was a statistically significant positive dynamics in the attention indicators within the low level. Visual memory reached the lower norm, and auditory-speech memory improved

within the reduced values (see *Table 1*). There were no statistically significant changes in the indicators of the emotional sphere.

The experimental group after the rehabilitation and psychological treatment was characterized by statistically significant positive dynamics for all the cognitive sphere indicators in question (see *Table 1*). Visual memory indicators reached their average norm, auditory-speech memory approached the standard values, and attention indicators corresponded to the level below the average. Statistically significant positive dynamics of the emotional sphere was observed in the indicators of unconscious and conscious anxiety and depression. After the rehabilitation and psychological treatment in the experimental group there were no patients with a subclinical level of anxiety and depression.

*Table 1*

**The effectiveness of rehabilitation and psychological treatment in the experimental and control groups (*Mdn* [*Q1*, *Q2*], scores)**

| | Control group ($n$ = 21) BEFORE, AFTER | $Z$ | $p$ | Experimental group ($n$ = 20) BEFORE, AFTER | $Z$ | $p$ |
|---|---|---|---|---|---|---|
| Visual memory | 3 [2, 4.5], 5 [4, 6,5]* | –3.648 | .000 | 4 [3, 5.75], 7 [6.25, 73.5]* | –4.053 | .000 |
| Attention volume | 83 [57.5, 106], 80 [54.5, 100.5]* | –3.808 | .000 | 81.5 [57, 90], 62 [49, 73.5]* | –3.927 | .000 |
| Attention distribution | 155 [117, 168.5], 132 [112, 170]* | –2.904 | .004 | 136 [100.25, 160.5], 100 [84.5, 122.5]* | –3.921 | .000 |
| Attention switching | 82 [63, 109.5], 71 [45.5, 83.5]* | –3.318 | .001 | 79 [54, 94.5], 60,5 [36.7, 73.75]* | –3.921 | .000 |
| Immediate recall | 3 [2, 4], 4 [3, 5]* | –2.739 | .006 | 4 [3, 5], 6 [4.25, 6]* | –3.100 | .002 |
| Number of recalling all the 10 words | 0 [0, 0], 0 [0, 1] | –2.236 | .025 | 0 [0, 0], 0 [0, 1] | –2.264 | .008 |
| Delayed recall | 5 [3, 5.5], 5 [5, 6] | –2.074 | .038 | 4 [2.25, 4], 6.5 [4.25, 8] | –3.203 | .001 |
| Unconscious anxiety | 2 [2, 3], 3 [2, 3]* | –1.542 | .123 | 3 [2.5, 4], 1.5 [1, 2]* | –3.886 | .000 |
| Anxiety | 4 [1.5, 6], 2 [1, 5]* | –1.145 | .252 | 4 [2, 6], 1 [1, 2]* | –3.336 | .001 |
| Depression | 3 [0, 5], 5 [1, 3]* | –0.909 | .363 | 3.5 [3, 5.75], 1 [1, 1.75]* | –3.426 | .001 |

*Note.* The Wilcoxon T-test; * means statistically significant differences between the groups.

Comparison of the psychodiagnostic test results for the two groups after the rehabilitation and psychological treatment revealed statistically significant differences in vi-

sual memory ($U = 63.50$, $Z = -3.905$, $p = .000$), attention volume ($U = 127$, $Z = -2.167$, $p = .03$), attention distribution ($U = 110$, $Z = -2.610$, $p = .009$), attention switching ($U = 132$, $Z = -2.037$, $p = .042$), immediate recall ($U = 94.50$, $Z = -3.097$, $p = .002$), unconscious anxiety ($U = 68.50$, $Z = -3.845$, $p = .000$), conscious anxiety ($U = 138.50$, $Z = -2.049$, $p = .034$), depression ($U = 136.50$, $Z = -2.134$, $p = .033$). In the experimental group, attention indicators were significantly lower, which indicates a higher level of attention processes, while other psychological indicators also showed higher values compared to the control group results.

Cognitive training results also reveal a more pronounced positive dynamics in the experimental group. Patients of the experimental group achieved a higher level in the training programs; they demonstrated a higher rate and a better quality of responses (see *Table 2*).

*Table 2*

**Comparison of the effectiveness of cognitive training in the experimental and control groups (*Mdn* [*Q1*, *Q2*], the level of training — scores; the average response rate — ms; the number of timely responses — scores)**

| | | *Es,* the experimental group ($n = 20$) | *Es*, the control group ($n = 21$) | *U* | *Z* | *p* |
|---|---|---|---|---|---|---|
| NBACK | The level of training | –3 [–3, —1.25] | –2 [–3.5, —1] | 121.00 | –2.965 | .041 |
| «SELECT» | The level of training | –4 [–5.75, —2.25] | 0 [–2, 0] | 44.00 | –4.397 | .000 |
| | The average response rate | 344 [210.5, 475.25] | 259 [169.5, 420.5] | 90.00 | –2.356 | .036 |
| | The number of timely responses | –42.5 [–59, —28] | –14 [–24, —9] | 60.50 | –3.901 | .000 |

*Note.* The Mann–Whitney U-test.

The BFB-training in the experimental group resulted in a decrease in the study participants' heart rate (HR) and skin conductance (SC) and an increase in their hand temperature (HT) and electrical skin resistance (ESR) (see *Table 3*). These changes indicate that the relaxation effect was obtained and the psycho-emotional state was improved.

*Table 3*

**Dynamics of average values of psychophysiological indicators within the BFB relaxation training in the experimental group ($n = 20$) ($M \pm SD$; SC, ESR — ms; HT — °C; HR — bpm)**

| Indicators | At the beginning of the training | At the end of the training | *t* | *p* |
|---|---|---|---|---|
| SC | 2.33±2.08 | 1.55±1.02 | –3.323 | .000 |
| ESR | .003±.006 | .067±.28 | 5.275 | .003 |

*Table 3 (continued)*

| Indicators | At the beginning of the training | At the end of the training | *t* | *p* |
|---|---|---|---|---|
| HT | 32.42±2.57 | 33.41±1.82 | –2.018 | .048 |
| HR | 76.03±9.99 | 71.12±10.94 | 2.542 | .020 |

*Note.* Student's t-test.

In order to evaluate the effectiveness of rehabilitation and psychological treatment, we performed a correlation analysis between physiological indicators, data from the techniques used and cognitive training. A positive relationship was obtained between attention distribution ($r_s = .686$, $p = .001$, $n = 20$) and attention switching ($r_s = .467$, $p = .038$, $n = 20$) and skin conductance. Attention distribution was also positively related to heart rate ($r_s = .573$, $p = .003$, $n = 20$). Lower values of attention, characterizing a higher level of development of this process, were observed when the physiological values were decreasing, indicating a decrease in the activity of the sympathetic nervous system and a reduction in negative psycho-emotional states.

Correlations were revealed between hand temperature and immediate recall ($r_s = .490$, $p = .028$, $n = 20$) and unconscious anxiety ($r_s = -.478$, $p = .033$, $n = 20$); therefore, the relaxation effect observed when the hand temperature increases, improves immediate memory and reduces anxiety.

The study participants' response rate was positively related to skin conductance ($r_s = .472$, $p = .036$, $n = 20$) and negatively with electrical skin resistance ($r_s = -.532$, $p = .016$, $n = 20$). The results obtained correspond to the knowledge about the effect of electrical skin activity on the response rate (Christopoulos et al., 2016).

## Discussion

A statistically significant improvement in cognitive functions observed in the control and experimental groups is due to the direct impact of cognitive training aimed at correcting the attention and visual memory functions. An improvement in auditory and speech memorization that was not specifically affected is probably due to the "transfer" effect, which involves transferring the improvement in cognitive functioning to adjacent non-trainable cognitive functions (Velichkovsky, 2009). The effectiveness of using cognitive training to restore reduced cognitive functions in patients with acute cerebrovascular disorders is mainly due to neurodynamic disorders of cognitive processes.

The BFB-training based on the skin conductance parameter leads to stabilization of patients' psycho-emotional state before cognitive training, thereby increasing the effectiveness of the latter on. Additionally, the relaxation effect observed in the process of BFB-training contributes to the improvement of cognitive functions (Sutarto et al., 2013; Trofimova et al., 2018; Marinina, 2019). The relationship between cognitive functions,

emotional state and physiological processes explains positive results of the rehabilitation and psychological treatment.

However, some limitations should be noted. First, our study has a relatively small sample size of participants. Increasing the sample will help to increase the statistical significance of the results in future studies. Second, we not used the location and type of stroke in patients. Probably, taking into account these features can influence the dynamics of changes in psychological parameters.

## Conclusions

A purposeful impact on memory and attention processes by means of cognitive training using specialized programs causes positive dynamics not only in the cognitive functions that are actually trained, but also in those that are not in question, thereby expanding the area of positive influence on post-stroke patients' cognitive functioning. An additional inclusion of BFB-training in the course of rehabilitation and psychological treatment helps to increase the effectiveness of cognitive training by stabilizing the psycho-emotional state, as well as by providing a positive impact of biofeedback methods on cognitive functions. Working with the current psychological state of patients with acute cerebrovascular disorders before conducting rehabilitation and psychological treatment improves their quality and effectiveness.

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# The Experience of Personal Time in Alzheimer's Disease

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# Переживание личного времени при болезни Альцгеймера

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**Background.** Alzheimer's Disease (AD) is a neurodegenerative illness, which occurs with increasing frequency as people age, and is currently a disease beyond curative therapeutic possibilities. While progressive memory impairment is the upfront element associated with the disease, other neurocognitive problems are also associated with it, such as language impairment that tend to degenerate into aphasia. The paper presents singular representations of time in such patients' lived experience, which with the course of the disease gradually move away from the real present around them. In consequence, they live in a bygone era. The dimension of the perceived world implies an anchoring in temporality in the present by using the resources of the past. This becomes impossible with the progression of the cognitive disorders. Multiple psychological tensions result from patient's maladjustment to temporality.

**Objective.** The article attempts to define the singular experience of the time of the demented patient according to the phases of the disease.

**Design.** An analysis of the psychological tensions summoned at the various stages of the disease was carried out using a semiotic methodology.

**Results.** The progression of the disease gives way to another mode of relation to the world, presentism. With its course, emotions can no longer unfold. At first, the patient seeks to increase his grip on the surrounding world, and the internal psychological tensions are accentu-

ated. Suddenly the world ends up completely escaping him, and catastrophically the internal tensions collapse. The patient slides irreversibly towards regression.

**Conclusion.** If the emotional intensity of what the patient experiences is enough, he remains engaged in the time of a presence in the world, even if it is distinct from the reality of those around him. When the intensity collapses, the demented patients disengage from it. The caregivers or families who take care of them can understand the mechanisms involved in the patients' experience of time. This allows them to adapt their own behavior. Thus, they limit the risk of misinterpretation and induce certain behavioral disorders linked to their shift from the reality of the patients.

***Keywords:*** *Alzheimer's disease; dementia; emotion; lived experience; time.*

**Краткое введение.** Болезнь Альцгеймера (AD) — это нейродегенеративное заболевание, случающееся с возрастающей частотой при увеличении возраста, и в настоящее время находится за рамками лечебных терапевтических возможностей. Первым признаком болезни является прогрессирующее ухудшение памяти, но при AD возникают и другие нейрокогнитивные проблемы, например, речевое расстройство, имеющее тенденцию переходить в афазию. В статье описаны единичные представления времени в жизненном опыте пациентов с болезнью Альцгеймера, которые с течением болезни постепенно отдаляются от реального настоящего вокруг них. Фактически они живут в давно ушедшей эпохе. Измерение воспринимаемого мира подразумевает привязку к временно́му в настоящем посредством использования ресурсов прошлого. Это становится невозможным при прогрессировании когнитивных расстройств. Многочисленные психологические напряжения возникают в результате неправильного приспособления пациента к темпоральности.

**Цель.** В статье предпринята попытка определить единичный опыт переживания времени у больных с деменцией в соответствии с фазами заболевания.

**Дизайн.** Анализ психологических напряжений, вызванных на различных стадиях заболевания, проводился с использованием семиотической методологии.

**Результаты.** Прогрессирование болезни вызывает другой способ отношения к миру, презентизм. При этом больной уже не может выражать свои эмоции. Сначала пациент стремится усилить свою "хватку" за окружающий мир, и внутреннее психологическое напряжение также усиливается. Но внезапно мир полностью ускользает от него, и внутреннее напряжение катастрофически разрушается. Пациент необратимо скатывается к регрессии.

**Вывод.** Если эмоциональная интенсивность переживаний пациента достаточна, он остается вовлеченным в жизнь, хотя его восприятие и отличается от реальности окружающих его людей. Когда интенсивность эмоций резко снижается, пациенты с деменцией выпадают из реальности. Ухаживающий персонал или семьи, которые заботятся о больных, могут понять механизмы, задействованные в переживании пациентами времени. Это позволяет им адаптировать свое собственное поведение. Таким образом, уменьшается риск неправильного толкования поведения больных и можно предупредить определенные поведенческие расстройства у пациентов.

***Ключевые слова:*** *болезнь Альцгеймера; деменция; эмоция; пережитый опыт; время.*

## Introduction

Alzheimer's Disease (AD) is a neurodegenerative illness, which occurs with increasing frequency as people age, and is currently a disease beyond curative therapeutic possibilities. While progressive memory impairment is the upfront element associated with the disease, other neurocognitive problems are also associated with it, language impairment which can degenerate into aphasia in particular (Thomas, Billon, & Hazif-Thomas, 2018). This illness disturbs memory and alters the singular representations of time in patients (Luria, 1980). Consequently, with the course of the disease a patient gradually moves away from the surrounding reality, in a retrogressive movement. **The presence field of a patient refers him to the position he occupies there, to the perspective of his environment and to the decisional course as to a possible practice which could concern him.** This presence of the subject in time takes place in two successive movements. The first is related to the body, the other is discursive, which implies an interpretation, the wording of an inner speech to put into words the representation of the time of the world in which he lives. We will assume, within the framework of this reflection on dementia pathology, that the inner speech, as it was previously stated by A. Luria (1979), is a self-addressed voice necessary to fix the sensitive and consolidate the interpretation of the environment (Thomas et al., 2018).

In this context, it is worth presenting a microgenetic model of inner speech (see *Figure 1*) closely linked to the self (Pąchalska, 2020). Recent findings suggest that AD may be associated with deficient self/non-self differentiation over time despite a relatively intact body image (Bond et al., 2016). According to M. Pąchalska (2020) inner speech appears in relations to the actual type of drive or desire. The text formulated in the inner speech is brought out from the working memory buffer only after the drives and desires empowered by emotions are transformed into logically and spatially comprehensive linguistic and nonlinguistic images. That text may be kept in the buffer of the working memory for some time,[1] forming the working self and then moved to the long term memory storage (Brown, 2004).

Most of the time it may be only the inner speech taking a form of the internal monologue (talking to the imaginary representation of oneself) or the internal dialogue when an individual talks to an imaginary other person (this may have a relatively abstract nature). It needs to be stressed that the form of internal dialogue may differ from utterances used in a communication act (Miyake, Emerson, Padilla, & Ahn, 2004). The internal text may be preserved for significant cognitive, emotional of axiotic reasons in the long term memory and starts to be one of the components of the longitudinal (autobiographic) self (Araujo, Kaplan, & Damasio, 2013).

It is worthy pointing out that inner speech enables the planning of action (Luria, 1973), and precedes making decisions (acts of will) both in trival and important matters. A process of passing from a given drive to recording the text in the working memory

[1] The buffer of working memory keeps the text for about 30 seconds, and even longer off line. It is a so called absolute now (Brown, 2015).

takes little time due to the effective executive functions and as a rule is realized as outer speech. It usually finishes one of many acts of the inner speech. However, in the case of really significant matters, or while making important and/or difficult choices between goals that are contradictory, the internal monologue may take a stormy form, full of contradictions, recurrences, and hesitations. It need not end with creation of a text that can be passed to the working memory or to the long term memory to become a component of the longitudinal self. It results in putting off decisions, difficulties in making a shift of action, etc. An individual with a healthy brain (without cognitive disorders — including speech — and without emotional impairments), with intact articulatory organs is able to communicate, i. e., externalize his/her inner speech in two ways:

- talking to oneself (self instructions, reprimands or praises);
- talking to others.

In AD persons with disorders of cognitive and emotional processes inner speech is reduced or absent and does not control behavior. Moreover, their inner speech will not exteriorize as a self-talk or talking to others, and it may become noncommunicative (with language errors). We have no immediate access to inner speech but we are ablle to gather some knowledge (information) about it thanks to nonverbal forms and means of communications such as pictures, photos, pieces of music, pantomime etc.

New brainimage technologies make possible the recording of occurrences of inner speech (Kropotov, 2016; Pąchalska, 2020). Experiments are usually conducted on healthy and fully conscious people. There are also studies that reveal an occurrence of inner speech in patients with minimal consciousness (Clowes, 2007) who were awoken from a postraumatic coma as well as in AD patients (Bond et al., 2016). Modulation of activity during generation of inner speech is frequently in temporal cortex (Shergill et al., 2002) however recent studies show that in these cases most active are: insula and Broca's area (Alderson-Day & Fernyhough, 2015), which are also activated in the cases of external speech[2] (see *Figure 1*).

Differences in tasks used to evoke inner speech may lead to its various forms. Some may provoke an expanded form of inner speech (both internal monologue and dialogue), others may induce only inner monologue, while those that stimulate verbal thinking may not induce the inner speech (Dolcos & Albarracin, 2014; Brown, 2004). Self-talk is a pulsing phenomenon, and can range from positive evaluations of the self in the form of self-encouragement, self-compassion, and self-affirmation to negative evaluations in the form of self-criticism, rumination on negative self-aspects, and expressions of inadequacy or worry (Brown, 2002, 2004; Dolcos & Albarracin, 2014).

This inner speech is altered by dementia and aphasia in the course of the Alzheimer's disease (Langland-Hassan, Faries, Richardson, & Dietz, 2015; Fama, Hayward, Snider, Friedman, & Turkeltaub, 2017). The dimension of the perceived world implies an anchoring in temporality in the present using the resources of the past: a lived experience

[2] Appearance of phonological associations in memory may cause internal auditory experiences or inner speech, which is linked to experiencing the voices of others.

(presentification) (Husserl, 1996). We will see that with the progression of the disease, it gives way to another mode of relation to the world, presentism (Minkowski, 2013), an era where only the present exists.

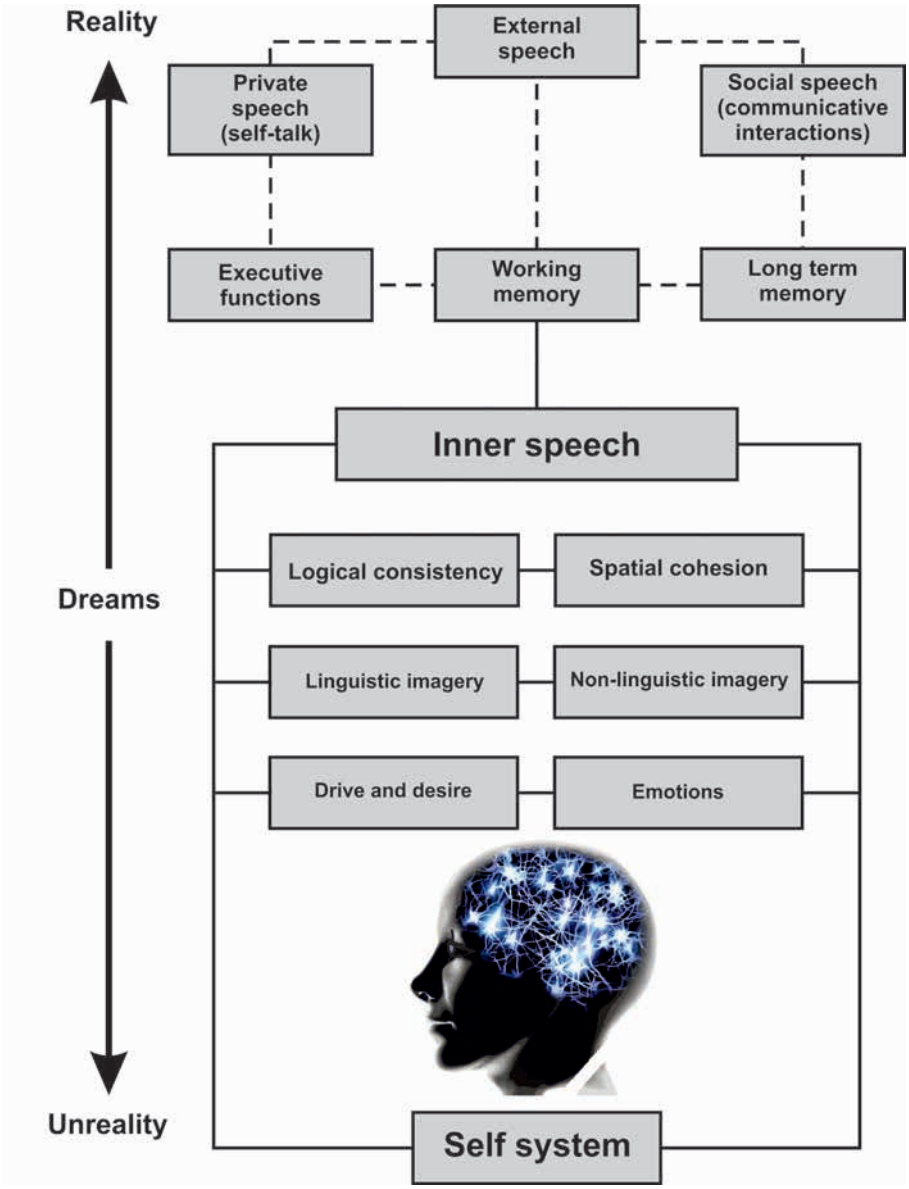


*Figure 1.* Microgenetic model of inner speech and self system. Processes, which are not (but might be) activated during the inner speech are marked with a broken line. Reprinted from "Inner Speech in MCI and Alzheimer Disease", by M. Pąchalska, 2020, *Acta Neuropsychologica, 18 (1),* p. 21. Copyright 2020 by the Agencja Wydawnicza Medsportpress. Reprinted with permission

## Reminder on the Tensive Model

Reflection on the tensive model was introduced by J. Fontanille (1998) and C. Zilberberg (2000) based on analysis of Binswanger's psychopathological space (Binswanger, 1998). The tensive space is defined in two valences which combine the intensity and extensity. By analogy to the definition of the two planes of language (Hjelmslev, 1968), the intensity characterizes the domain of internal, interoceptive feeling, the origin of stimuli coming from the organism itself. It will become the content plane: the interoceptive for the feeling body and the psyche integrating these data into proprioceptive schemes. The plane of the signifiers is the extensity, the external domain in which the emotional intensity can be grasped and developed (extensive deployment): the exteroceptive, the origin of stimuli coming from the external world and the sensor-motility for perceive emotions through the body (Fontanille, 2004; Minkowski, 2013). It will become the plane of expression, the plane of signifiers (Fontanille, 1998).

### Intensity and Tensive Extensity

From the combination of intensity and extensiveness arises the subjective aspect of a situation or event, allowing the taking of a position and of a lived experience of one's own body (Zilberberg, 2000). Intensity refers to an emotional and affective dynamic, intensity to a cognitive dynamic, to the intelligible. These two dimensions come under the semiotics of the construction of the psychic continuum. Intensity and extent are gradual, open, orientable and reversible dimensions, which can be represented on a diagram expressing on the ordinate the gradient of the intensity and on the abscissa that of the extensivity (see *Figure 2*). Depending on whether the intensity of an event is low or strong, low (diffuse) or high (concentrated), four zones are delimited in this diagram, defining four types of emotions, flat, bright, radiant, empty.

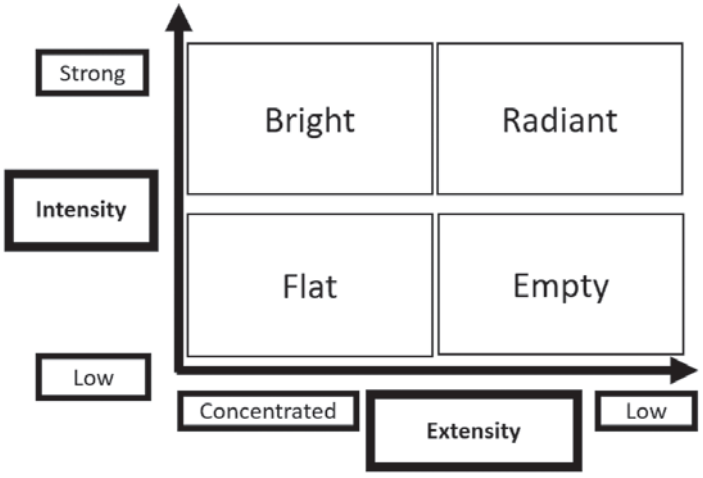


*Figure 2.* Tensive model. Two valences: Intensity and Extensity.
S o u r c e: Zilberberg, 2000

An emotionally intense event can be experienced as vivid, overwhelming the psyche, if there is no space to flourish. It will appear to be radiant if the person has the time and space to listen or express themselves. Another event without great emotional mobilization and with a more limited or impossible access to be deployed, for example due to severe disabilities to invest, will be considered flat. A similar event weakly emotionally mobilizing, if a deployment in available space and time potentially exists, will be regarded as a void of interest.

Intensity and extensity combine in the perception of objects and events, as well as with the relative positions of the subject in relation to his environment, sometimes source sometimes target depending on his ability to exercise control. The person can have control over his environment and can experience inner freedom. She can depend on and undergo her environment, losing both her physical and psychological autonomy. Intensity and extensity are the patient's first articulation of his presence in the time of the world.

The intensity and extensity are each broken down into two sub-dimensions, two sub-valences, respectively for the intensity, the tempo with which an event occurs (progressiveness or, on the contrary, violent emergence) and its tone (emotional mobilization strong or peaceful); and for the extensity, the temporality (the length of time to work out what is going on) and the spatiality (the possibility of understanding, of working out, of expressing oneself orally or through actions). Spatiality and temporality represent the possibility of extensive deployment of an emotion. The division of these two intensive sub-valences and of the two extensive sub-valences can be done according to the three dimensions mentioned by Binswanger in relation to psychopathological space, position (the lived event is adapted to the logic of the person, to what the person is or on the contrary it strikes, thwarts), the direction (freedom, opening of the world to oneself or on the contrary prohibited, inaccessibility of it), finally the impetus or the motivation to live what is present (Binswanger, 1998).

**The Efficiency Mode**

The mode of efficiency is the way in which an event is likely to enter the field of presence (Zilberberg, 2000), in an inchoative (predictable) or, on the contrary, in an unexpected way, with a brutal tempo, with a limited space and a time for an elaboration. The modes of efficiency thus distinguish the occurring, more generally outside human control and the achieving which presupposes an elaboration, a sustainability and a progression (see *Figure 3*).

The efficiency mode opposing the happening to the happening allows us to envisage a semiotics of the event (Zilberberg, 2011). The mode of occurring (impromptu irruption of a visitor in the patient's room), referring to the unpredictability of the sense, to the unusual of the situation and when associated with a strong intensity, it is violent, concentrating on a brief temporality the events in terms of extensity. The mode of achieving, on the contrary allows to manage a low intensity with a moderate tempo (the caregiver knocks on the door and slowly enters the room of a patient), with the elements of the intensity manageable, controllable, even familiar. The memory disorders of Alzheimer's disease depriving the patient of access to the past as a resource in the present and to anticipate the future, transforms

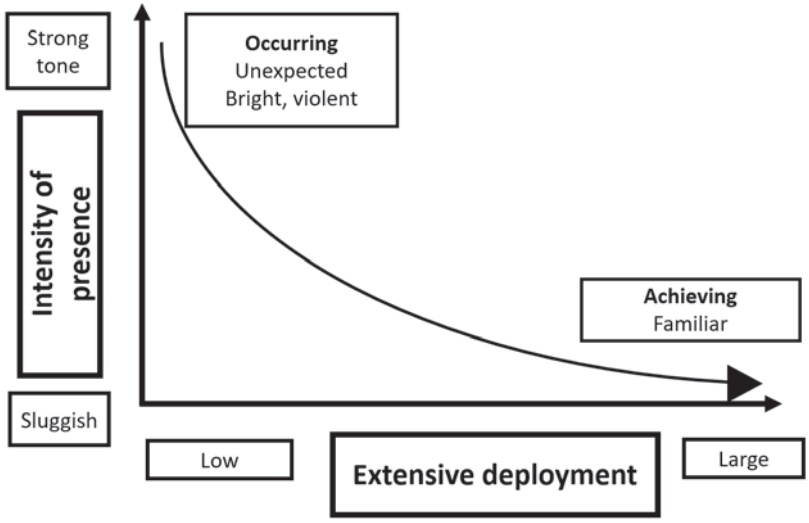


*Figure 3.* Tensive model. Two modes of efficiency in tension: to arise and to succeed.
S o u r c e: Zilberberg, 2000

a banal event into something unexpected that occurs in the field of consciousness (Hazif-Thomas, Thomas, & Sutter, 1991). The patient no longer has access to an elaboration to project himself in time and space, the extensivity is closed to him. The demented patient is in a presentism (Minkowski, 2013; Thomas, Clément, Hazif-Thomas, & Leger, 2001).

## The Tensive Model and Dementia

Tensive patterns are greatly disrupted in dementia. The links between the intelligible and the sensitive are untied and unraveled due to cognitive disorders. The sensitive thus tends to impose itself on the psyche of the demented person. The tensive schema still intervenes in memory reminders, memories strongly marked on the emotional level (Fuzzy traces Gist) are more solid than the others (Fuzzy traces Verbatim) (Brainerd & Reyna, 2001).

### Modes of Efficiency and Dementia

In dementia, the mode of efficiency is involved in the perception of self-image in a mirror. In the twilight of reason, Maisondieu (2011) emphasizes the patient's fear of looking at it. A demented patient lives in a remote time, with representations of the world and himself very far from the present. Brutally discovering one's aged image reflected by the mirror, a way of a too fast happening, is certainly a return to reality, but also a violent and unexpected confrontation. When the patient has a daily toilet in front of the mirror, he sees himself changing, with the insensible transformations as the years go by. It is in the mode of achieving, it does not manifest violence or rejection.

**The Inversion of Tension Patterns and the Disappearance of Space Limits in Dementia**

First, we will look at the dimension of the patient's experience of space depending on whether extensivity is completely open or whether he closes with the course of the disease. He opposes the simple opposites of the open and the closed, and to the extreme the hermetic (the inaccessible) and the gaping (the open without limits).

*Figure 4* shows the spatial tensive evolution of a demented elderly person when the disease progresses. We will take the "open" reference position of a person who makes moderate efforts to access a world that is still accessible to him/her, who is normally stressed in daily life, who can add some meaning to the perceived world without great psychological difficulties.

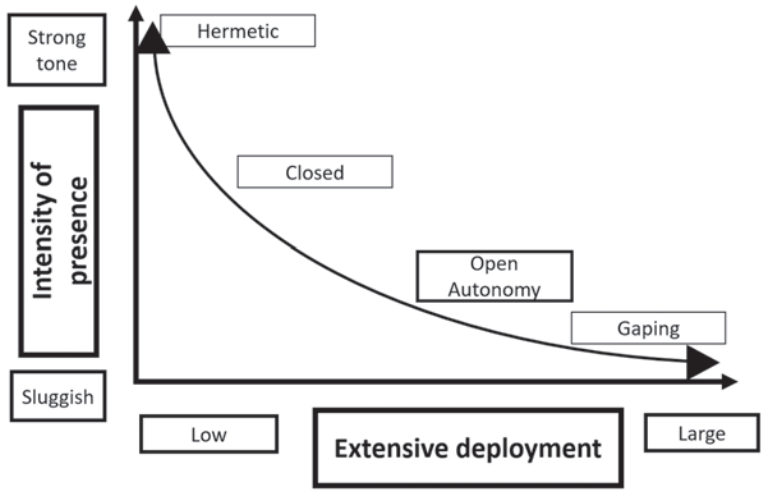


*Figure 4.* Tensive spatial evolution of a demented person with the progression of the disease. S o u r c e: Zilberberg, 2011

When the disease progresses, the outside world as the sick person perceives it, remains a target to establish his authority over the world. His position in the everyday environment, however, tends to gradually close. He has less easy access to usual services. Shopping becomes less easy, shops in the immediate vicinity are more and more often chosen. The patient is forced to use more energy to support himself and has more difficulty finding help, to maintain both physical and psychological autonomy. Gates to access help or support oneself every day are not always easy to open. The patient intensely seeks to increase a grip on his/her shrinking living territory. He often becomes authoritarian and more rebellious to even small changes.

The patient ends up being dependent on the environment which he no longer controls, which he tries to overcome. He is no longer the source of what he experiences daily, he becomes the target of the external services on which he depends. The world around him becomes a source that provides for his needs, which the patient is far from mastering. When addiction has taken hold, the sick person is exposed to two contradictory movements which

depend on the conditions of the possibilities of access to the extent of what is necessary for him to live and to express his feelings. Tense or fleeing, these movements often alternate according to the moments or the days. Sometimes, he tenses up on a banal situation, refuses care, violently rejects any relationship. At home, he refuses to see his family or friends, in a retirement home, she refuses to participate in recreational activities. In short, he refuses anything that could relieve his tension. At other times, he tries to flee his situation. He runs away from home; he gets lost in the immediate environment. This position is hermeticism.

Sometimes at the more advanced stage of the disease, the demented person gives up, suddenly letting go of everything that bothers him and he becomes indifferent to any constraint. He neglects the rules of good living and hygiene standards. He has unbridled behavior, unjustified aggressiveness towards others. This is a gaping position, without great tensive intensity but without limit of intensity. The icon for this position is the figure of Tatie Danielle in Etienne Chatiliez's film.

### The Inversion of Tension Patterns and the Disappearance of Time Limits in Dementia

We will examine in this second part the temporal perspectives in the tensive diagrams convened by the progression of the disease. The loss of memory condemns the patient to live in a presentism (Hartog, 2003) which supplants the possibilities of presentification. The past is no help for the present, the future impossible to imagine. The patient is somewhat distant of the present moment, living in a past which is still accessible to him.

We will take as reference position longevity and duration in the sense of Bergson (2012), the length and the enjoyment of a time, which concerns a person still moderately affected (see *Figure 5*).

The attention required to understand what is happening around the sick person is moderate. The time required to understand his environment and elaborate his perceptions is sufficient so that the demented person is present to himself, adjusted in the time of the world.

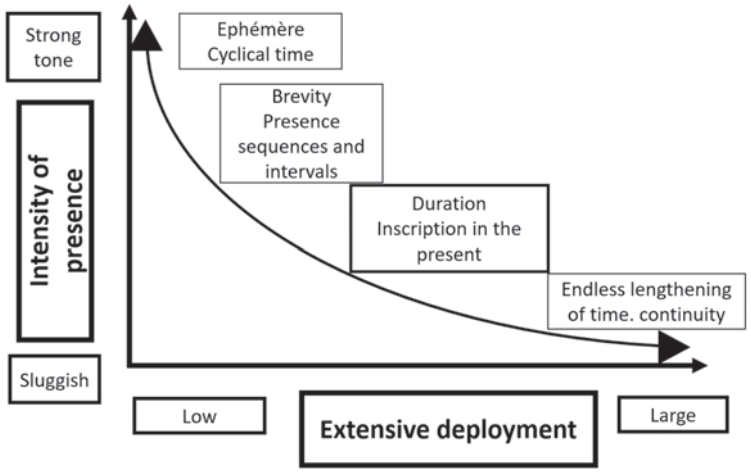


*Figure 5.* Temporal tensive evolution and progression of the disease.
S o u r c e: Zilberberg, 2011

As the disease progresses, the times of attention, of presence in the world or in others shorten and divide. The patient is exhausted in mobilizing his attention to grasp an environment that is increasingly complex for him. The emotional intensity is even more marked since his capacity for expression diminishes with aphasia. He expresses himself to those around him with renewed labile interest aroused by a few events or by a visit from a relative or friend. But his attention and interest quickly disappear. His speech becomes impoverished, testifying that with language disorders, the construction of his ideas become sketchy. His presence in time is breaking out. The person seems to live inwardly but briefly, with long intervals of silence and disinterest.

The difficulties encountered by a patient with AD can be explained by symptom formation according to a microgenetics theory (Pąchalska & Kaczmarek, 2012), developed in accordance with the syndromological analysis proposed by A. Luria (1979), and symptom formation after brain damage (Brown & Pąchalska, 2003).

## Destabilization of the Models of Conscious Self in AD

Further development of AD disease and the associated loss of neurons and neuronal connections causes serious disturbances of working memory. Models of the conscious minimal (working), and longitudinal (autobiographial) self that have existed so far at three hierarchical levels of the brain create in a highly complex "system of systems" characterized by the exchange of information from different systems (Stuss, Rosenbaum, Malcolm, Christiana, & Keenan, 2005; Pąchalska, 2020).

1. Luria (1973) notes that these models use the functional units of the cortex. The first functional unit of the cortex is the sensory unit. The dark blue-shaded areas are primary zones; medium-shaded are secondary zones; light-shaded areas tertiary zones. Sensory input travels from primary to secondary, then to the tertiary zones, and is thereby elaborated from sensations into symbolic processes. Symbolic processes are in turn translated into intentions in the tertiary motor zones and then into patterns of action in the secondary and primary motor zones. Finally, a speech act is performed with the use of a motor unit, i. e. the second functional unit of the cortex (see *Figure 6*).
2. Pąchalska (2020) performed studies comprising 76 patients with AD taking into account Lurian functional units of the cortex. The studies revealed destabilization of a conscious self that occurred in three levels:

- *The third level (highest)* in which all informations are interpreted in the light of ones own biography, starting with the past and projecting towards the future. In AD persons processes making possible selfconciousness (ones own existences and action) as well as enabling selfreflection are disrupted. At the same time, transformation of information, modeling world image and the image of oneself is impaired. In consequence, an ability to correctly perceive others and ones own person is severely disturbed.

- *The second level (higher)* is concerned with trnsforming basic contents and/or knowledge of the world. Destabilization of this level is caused by a progressive disruption of posterior brain areas (reposible for visuo-spacial functions) as well as the primary motor cortex observed in AD. Maps of the body and of the world are formed at this level based on the information coming from various modalities (visual, auditory, amd haptic) due to the connections between particular areas. The above metioned disruptions result in destabilization of the models and processing of information is delayed, which at first creates difficulties in reacting to incoming stimulus, leading to inability to react after the illness progresses. Hence, the disorders of awareness observed at this level are as a rule specific to a given modality.
- *The first level (lower)),* concerned with continuous comparison of the existing models with new information, which enables their verification. As a consequence of disruption of many neuronal connections the model does not exist anymore, and all sensations, and experiences must be directly analyzed in the brain. Since working memory (both epizodic and autobiographic) does not exist the brain is not able to model the self, and the patients loses an ability to in an insight into the real world, and drifts in the time, space as well as in his surroundings.

It is in the cortex that perception and action reach the level of conscious decision. The brain forms articulated pictures or representations of what is out there in the world, and of what has been out there in the world, and the play of these images constitutes conscious perception. What is more — and this has only recently begun to be a subject

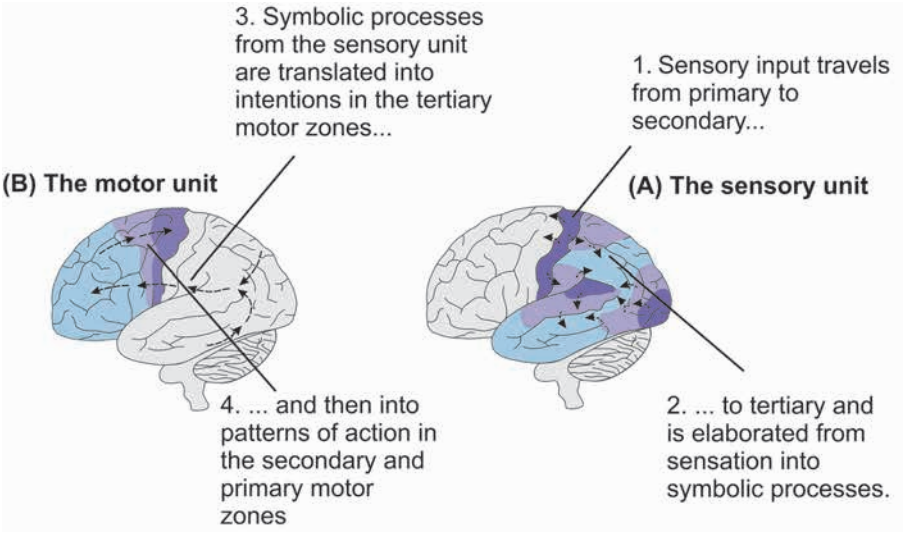


*Figure 6.* Lurian functional units of the cortex: (*A*) — the first functional unit of the cortex — the sensory unit; (*B*) — the second functional unit of the cortex — the motor unit. Reprinted from "Alexander Romanovich Luria (1902–1977) and the Microgenetic Approach to the Diagnosis and Rehabilitation of TBI Patients", by M. Pąchalska and B. L. J. Kaczmarek, 2012, *Acta Neuropsychologica, 10 (3),* p. 345. Copyright 2012 by the Agencja Wydawnicza Medsportpress

of interest for neuropsychology (Pąchalska, MacQueen, & Cielebąk, 2018) — the cortex is capable of forming pictures and/or images (see *Figure 7*) of what might be or could be out there, or could have been, or should have been, and was not.

It is not that hard to form a coherent theory of how the brain forms an image of something that the eyes see or have seen, but it is quite another thing to explain how the "mind's eye" works in terms of brain structure and function. For the present purposes, however, the most important fact about the cerebral cortex is that both perception and action at this stage are characterized by detail, discrimination, and analysis. The reptilian brain sees a large moving object, to be avoided, or seized, or ignored; the paleomammalian brain sees a human figure, producing an affect, positive or negative; the cortex sees features, details, a face, and can put a name to it, or not. The complexity of perception results from the fact that these three images come into existence independently and sequentially, though there is only one perceiver and one object, and the entire process takes milliseconds to complete. The conscious mind, then, typically experiences its perception as a single, simple

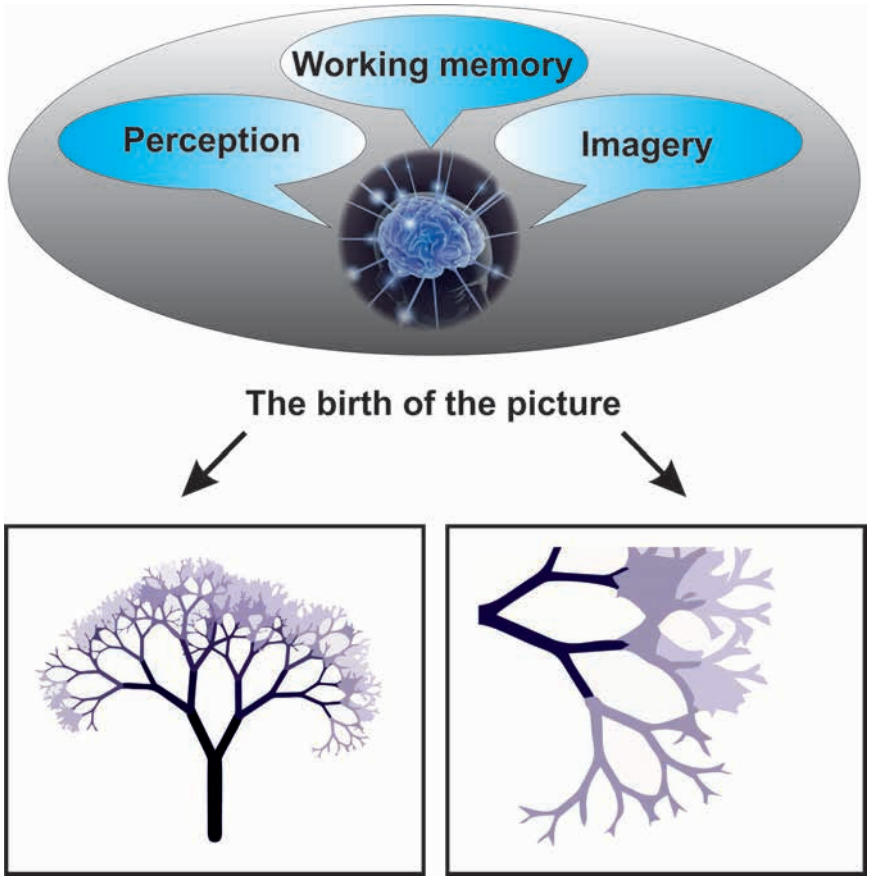


*Figure 7.* The birth of the picture. Reprinted from "Creative Potentials of Microgenetic Theory", by M. Pąchalska, B. D. MacQueen, and K. Cielebąk, 2018, *Acta Neuropsychologica, 16 (2),* p. 134. Copyright 2018 by the Agencja Wydawnicza Medsportpress. Reprinted with permission

act of seeing. According to microgenetic theory, however, this single act is a multi-layered actualization, the tip of an iceberg that floats to the surface and then subsides, containing within itself the traces of all that has gone before, in phylogeny, ontogeny, and microgeny (Pąchalska, MacQueen, & Brown, 2012).

As objects take on their objective character in a sculpting process constrained by sensory data, time becomes a dimension of the subject-object system, along with space, which expands beyond the arms reach and the immediate visual field. The mind can conceive of places other than "here", and time other than "now". There is past, present, and future, which come into existence as concepts when the fluid before-and-after sequences of limbic time are projected out into the world and fixed to something that at least seems to be objective. This is not to say, of course, that the time of our consciousness is the same as clock time, or even that our ordinary assumptions about the three domains of time (past, present, future) are as natural or self-evident as they may seem. As Brown (2015) continually reminds us, time is a central issue for microgenetic theory, where the crucial point is the duration or "thickness" of the "now". Given that time-space is actually a continuum, the "forward" movement of time is more a psychological than a physical fact. The past is a construct that is created and recreated at each moment of the now; the future is an extrapolation resulting from the experience of a certain "forward" momentum in the resurgence of the "now" over the rapidly receding past.

Thus, from the physical (and metaphysical) point of view, the present is a dimensionless boundary between the fully actualized past, which having exhausted its potential no longer exists, and the potential future, which does not yet exist. When an arrow is shot from a bow at a target, its flight seems a single event, but this is a psychological fact, and not a physical one (Fernyhough, 2013). Whether or not the arrow strikes the target at which it was aimed depends, of course, upon a number of variables: the skill of the archer, the distance, the wind, the movement of the target, etc. At the moment the archer releases the arrow, the range of possible outcomes is still very wide. With the proper video equipment, however, we can break this event down into a series of states, frozen on film, and at each of these "nows" the number of possible trajectories is significantly reduced, as is the number of possible interfering factors. With each successive frame, then, it becomes easier to predict whether or not the arrow will strike the target, and at some point it becomes reasonably easy to predict exactly where it will strike the target. At 100 milliseconds before impact there is no real doubt what is about to happen.

The point of this example is that every mental act is in fact played out in the same way as the flight of this hypothetical arrow, and this is what forms the essence of time as the cortex learns to manipulate it. In fact, though the time in which cortex operates may seem more objective, closer to the fourth dimension of physical objects than the free-floating sequences of limbic time, the operations involved in creating past, present and future are ultimately subjective in nature.

When the disease is still progressing, the brevity of the effect of the inner events of the sick person turns short-lived. Chaos seems to have taken hold of his ideas. He only lives in fits and starts, sometimes explosive, screams, violent gestures without reason and

at the slightest stimulation, before plunging back into silence. It can still get lost in verbal stereotypes many times punctuated, like a broken record, in a circular time, without any range from the point of view of the extent because the words and the articulated sentences are disjoined of all directions (Gazzaniga, 2011).

In this context, it is worth recalling that the brain communicates with two codes: electrical and chemical. The firing of a given neuron is associated on the one hand with specific neurochemical changes and with the activation of patterns of various neuronal connections connecting with other neurons, which causes further specific neurochemical changes (Pąchalska, 2019). In severe, neurodegenerative brain damage, as is the case of AD, brain systems are disturbed. Depending on the extent of the neurodegeneration, they may affect one, two, three or all brain systems and related neurotransmitters (see *Figure 8*).

The destabilization of individual motor and sensory functions as well as language and pragmatic functions creates a new, complicated and time-varying dialectics, which is associated with the processes of neuronal loss, the breakdown of various connection patterns, and the associated metabolic and chemical activity of the brain in AD (Kropotov, 2016).

*Can we imagine how an AD patient feels with such a destabilization of neural network patterns?*

A healthy person can be confused in time and space in certain situations (after all, most of us experience a temporary sense of confusion in the first moments after waking up from sleep), but it is enough to find the right reference points and we immediately know where we are in time and space. In contrast, the patient with AD due to cognitive deterioration is unable to find such reference points and therefore his consciousness drifts in time and space (Pąchalska, Bidzan L., Bidzan M., & Góral-Półrola, 2015).

The use of Luria's approach to brain function as well as the new neuropsychological (see also Pąchalska, 2020) and neurophysiological studies (see also Kropotov, 2016) presented above allow the reader to better understand why in the very advanced stage of Alzheimer's

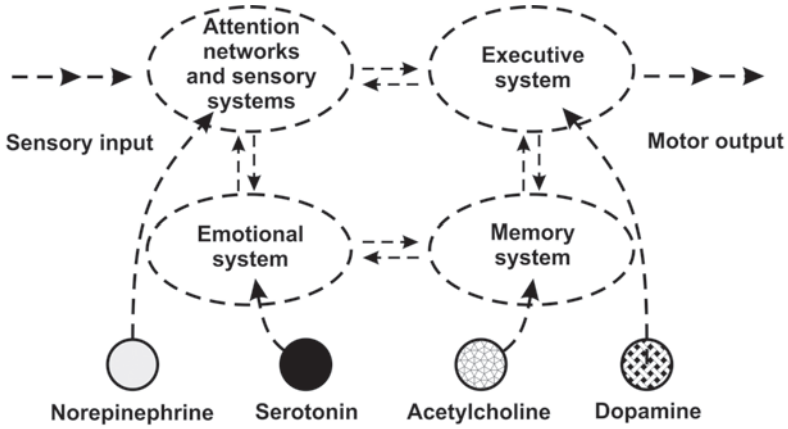


*Figure 8.* Deatabilization of brain systems and related neurotransmitters in AD. Reprinted from "Inner Speech in MCI and Alzheimer Disease", by M. Pąchalska, 2020, *Acta Neuropsychologica, 18 (1),* p. 23. Copyright 2020 by the Agencja Wydawnicza Medsportpress. Reprinted with permission

disease, the emotional intensity suddenly seems to go away, the person no longer seems to have internal tensions, he is apathetic. He always remains frozen in the same position. Time seems to no longer run out and be endless as if the interior life had been absent. It is for him the time of eternal permanence. Perhaps it alleviates or removes the anxiety of death.

Scholars and family believe that the patient's identity is not altered (at least in the classic sense of the term), however his minimal (working), and longitudinal (autobiographical) self is disturbed (Kertesz, 2006; Mendez, 1992, 2017; Pąchalska, 2020). Because of a serious memory problem, he cannot update the knowledge of himself and others and make changes in thinking about himself and others (eg. the patient doesn't know that his wife or husband died month or year ago).

Alzheimer's disease in the final stage leads to destruction of the body. The patient is completely dependent on the help of other people and must be constantly supervised. His speech is limited to a few words. During this time, delusional self-identification disorders, difficulties in recognizing relatives may occur (Mendez, 2017). There are also (in terms of Luria, 1973) complex disorders of individual, social and cultural identity. Hallucinations and disturbances of consciousness manifested as confusion gradually appear and the patient is finally excluded from family and social life (Pąchalska, 2020).

With the course of the disease, as the extent of his emotions becomes more inaccessible to the patient. He also loses his ability to laugh (Mendez, 2017). His space for deployment narrows, but, at first, the grip on the world increases and internal tensions are increasing. Suddenly the world ends up completely escaping him, this in a catastrophic way in the sense of Thom (1996), things are reversed, internal tensions collapse, and the extensive limits disappear. Everything becomes out of the patient's reach. He no longer distinguishes what he could do in his environment, he loses the anticipatory dimension that would allow him to build a minimum of project. In a few days, the patient puts himself in a regressive position which is very difficult to reverse.

The patient is bedridden, loses vital functions, it increases the risk of infection. He may have his eyes open, but he cannot see what is happening around him. It manifests anosognosia, i. e. lack of awareness of the disease (Orfei et al., 2010). This fact is of great importance for understanding the episodes of sporadic and uncontrolled impulsive actions. Psychological time is no longer relevant, as there are deep disturbances in self-awareness (Tulving, 2002). The patient seems to hear but does not respond to the environment. He is minimally conscious, almost like the patient awaken from post traumatic coma (Pąchalska, 2020).

The eyeballs are sunken and do not close the eyelids. Physiological changes are progressing. Heart rate is weak, shallow breathing and slower. The skin is colder and more sticky, cyanosis appears on the limbs and around the mouth. The sphincter control is disturbed, resulting in stool and urine incontinence. Body temperature drops (one degree or more), blood pressure decreases, pallor and cyanosis occur, and sweating increases. The breathing becomes irregular, wheezing and coughing are heard. The most common cause of death is pneumonia (Kertesz, 2006).

## Conclusion

If the emotional intensity of what the patient experiences is enough, he remains engaged in the time of his presence in the world. The world exists, but it is perceived as hostile and is rejected by the sick AD person. His identity is not altered (at least in the classic sense of the term) however his minimal (working), and longitudinal (autobiographial) self is disturbed. Because of serious memory problem, he cannot update the knowledge of himself and others and make changes in thinking about himself and others. Therefore, the other, the family or a caregiver, are experienced as disturbing and hostile, intrusive and threatening to the self. The patient violently opposes all solicitations, most often closing his eyes tightly so that he no longer wants to see external reality. When the intensity collapses, he disengages from the time of his presence in the world. He is indifferent. The world no longer exists for him, he no longer reacts to the presence of others. The patient slips into an irreversible regression. What then remains of his identity? The subject has withdrawn from the world and no longer seeks to communicate with it Time no longer matters to him. The words are hidden because of progressive aphasia, linked to the disease, but also to his psychology of withdrawing from his presence in the world. Understanding of the mechanisms involved in the patient's experience of time [especially in relation to minimal (working), and longitudinal (autoographial) self] by caregivers or the families who take care of them allows them to adjust care. They limit the risk of misinterpretation as well as induce certain behavioral disorders linked to the mismatch compared to the reality of the patient.

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# SCIENTIFIC LIFE

# НАУЧНАЯ ЖИЗНЬ

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# Cognitive Neuroscience: Challenge of the Time

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# Когнитивная нейронаука: вызов времени

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Ural Federal University named after the first President of Russia B. N. Yeltsin in Yekaterinburg welcomed participants of the II International Forum "Cognitive Neuroscience — 2019" in November 2019. More than 300 Russian and foreign scientists took part in the Forum. A total 85 reports were presented.

This article is the final report about the Forum. The article presents relevant research directions that have become the subject of discussion by the Forum participants, a scope of Forum research areas and prospects for the development of cognitive neuroscience in general.

***Keywords:*** *International forum; cognitive neuroscience; scientific meeting; psychophysiology; clinical psychology; neuropsychology.*

В ноябре 2019 г. на базе Уральского федерального университета имени первого Президента России Б. Н. Ельцина в г. Екатеринбурге прошел II Международный форум по когнитивным нейронаукам “Cognitive Neuroscience — 2019”. В работе форума участвовали более 300 российских и зарубежных ученых. Всего было представлено 85 докладов.

В статье рассмотрены тематические направления работы форума. Представлены актуальные исследования, которые стали предметом обсуждения среди участников форума, проведен анализ работы разных направлений форума и сделаны выводы о дальнейших перспективах развития когнитивной нейронауки в целом.

***Ключевые слова:*** *международный форум; когнитивные нейронауки; научное мероприятие; психофизиология; клиническая психология; нейропсихология.*

In November 2019, Ural Federal University named after the first President of Russia B. N. Yeltsin in Yekaterinburg hosted the II International Forum “Cognitive Neuroscience — 2019”. The main goal of the Forum was the development of international scientific relations, consolidation of scientific resources for breakthrough fundamental research in the area of neuropsychology, clinical psychology, psychophysiology and other areas of cognitive neuroscience. Forum became a continuation of significant scientific events in the area of neuroscience that were held at Ural Federal University, including the Fifth International Luria Memorial Congress (2017), I International Forum “Cognitive neuroscience — 2018”. More than 300 Russian and foreign scientists participated in the Forum.

The Forum program included plenary and breakout sessions, oral and poster presentations. There was also the young scientists section. The Forum covered 6 research areas: neurocognitive aspects of education; interdisciplinary research of the brain: age-related aspect; chronobiological aspects of psychological well-being and cognitive performance; philosophic and methodologic prospects of the cognitive researches; developmental psychophysiology; neurocognitive aspects of personality development in late adulthood. A total 85 reports were presented in the Forum.

Plenary session included the invited talks of world-recognized scientists in different areas of cognitive neuroscience.

Professor **Sergey Malykh**, member of the Russian Academy of Education, Head of the Laboratory of Developmental Psychogenetic of Psychological Institute at Russian Academy of Education (Moscow, Russia) gave the inspirational talk “Longitudinal researches of cognitive development”. He showed the importance of longitudinal approach in the investigation of brain and cognitive development. In particular, he presented the results of a big longitudinal investigation of development in school-age children. The talk of professor Malykh covered issues related to human neurocognitive growth at different stages of development, mechanisms of maturation of cognitive functions in typically and atypically developing children, psychophysiological aspects of growth.

Professor **Janna Glozman**, Research Director of the Research Centre of Developmental Neuropsychology named after A. Luria, leading researcher of Neuropsycho-

logical Laboratory (Moscow State University) presented the debatable talk "Cognitive neuroscience is not the same as neuropsychology: reasons and challenges". She showed a line between Neuropsychology and Cognitive neuroscience. Cognitive neuroscience was described as "an interdisciplinary approach that combines the efforts of cognitive psychology and neuroscience for study how sensory-perceptual and cognitive processes are implemented in the brain, including at the neural level". The representation of neuropsychology was presented from the point of view of the development of three historical stages. The first stage of neuropsychology is the research into brain organization of higher mental functions. The second stage is the analysis of the psychological structure of higher mental functions. The third stage is the analysis of the relationship between the patient with brain problems and the society in which he lives. Thus, the difference between cognitive neuroscience and neuropsychology is that the first branch of scientific knowledge explores the brain organization of cognitive processes, while the second is aimed at the study of cultural and social aspects of higher mental functions and their organization in the brain for the purpose of rehabilitation and adaptation to society.

Professor **Dmitry Zaitsev**, Faculty of Philosophy (Moscow State University), contributed to unraveling secret of investigation in the area of cognitive neuroscience in his talk "True Science of Argument and Reasoning: Logic or/and Cognitive Science?".

Professor **Alexander Kaplan**, Head of the laboratory of neurophysiology and neuro-computer interfaces (Moscow State University), presented the promising topic in modern cognitive neuroscience in his talk "Neurointerface technologies: achievements and prospects". A. Kaplan presented a survey of the current development of brain-computer interfaces (BCI) — the systems that establish direct links between neural activity and hardware, bypassing nerves and muscles. As the examples of BCI, Russian systems "Exowrist-2" and "Neurochat" were submitted. "Exowrist-2" was created by the Institute of Higher Nervous Activity and Neurophysiology and Lomonosov Moscow State University. It is based on the fact that the post-stroke patient, representing the movement of the alloy limb, controls a device that mechanically helps him to perform a movement. "Neurochat" was developed by Lomonosov Moscow State University together with the companies "Neurochat" and "Neurotrend" supported by the branch association "Neuronet" and the national technology initiative (NTI) Foundation. "Nerochat" is a technology in which the patient focuses on a specific letter. The system recognizes his reaction and fixes the letter in the message due to the P300's evoked potential.

Professor **Alexander Hramov**, Head of neuroscience and cognitive technology laboratory (Innopolis University, Kazan), shared with participants of the Forum the results of research in his talk "The relationship of spatio-temporal structure of EEG with human personality during performing simple cognitive tests". Khramov talked about relationship between cognitive processes and personal characteristics. He used EEG method in this research. Participants were asked to undergo the "Schulte Tables" test while EEG being recorded. According to the EEG outcome, the participants were divided into 3 groups based on the results of brain neurons individual activity. In addition, the participants

were also requested to complete a Cattell's 16 personality factors (16PF). It was shown that the neurons individual activity of these three groups was also different in such factors as cordiality, thinking, emotional stability and dominance. The results evaluating the respondents' mental abilities were also different.

Professor **Vladimir Popov** in his talk "Generation of deceptive actions by a robot to increase its own performance and safeness of interactions" raised the question of the possibility of artificial intelligence (robot) to generate deceptive actions in order to mislead another robot or person. A study was conducted with two robots, one of which could perform deceptive actions. Each of the robots had their own tasks which they could solve. It was shown that a robot that performed deceptive actions could mislead the second one, however, as a result of the study, a greater efficiency of both robots was achieved, and the frequency of collisions between two robots reduced while performing tasks.

Professor from Meiji Pharmaceutical University (Tokyo, Japan) **Yoko Komada** gave interesting talk in the practical-oriented topic on cognitive neuroscience "What is sleepiness? Association between subjective and objective". The results of the study showed a violation of neuropsychiatric function in sleep disorders such as sleep apnea and insufficient sleep syndrome, which in turn leads to an increased probability of road accidents.

Professor **Claes von Hofsten**, Uppsala University (Sweden), presented results of his world-recognized researches in the area of motor and cognitive development of infants in his talk "The early development of action skills".

At the end of plenary sessions, there was the **panel discussion** where the researchers in the area of cognitive neuroscience shared their thoughts about opportunities and risks in the modern cognitive neuroscience.

The section **"Neurocognitive aspects of education"** was devoted to using the neuroscience approach for investigation of different research topics in education. Researches presented and discussed the following topics: oculomotor indicators of emotional burnout syndrome (Lomonosov Moscow state University); professional evaluation in the solution of a cognitive problem (Russian National Research Medical University N. I. Pirogov); effects of the availability of information in the cloud storage on the memory of students (Ural State Pedagogical University); interrelation between cognitive development and success in learning Russian in native speakers from Russia, Kyrgyzstan and Moldova (Russian Academy of education). Special attention was paid to the development of professional deformations (V. V. Barabanschikova, A. A. Klimov). Presenters showed that relevant task is to develop new methods for reliable assessment of the severity of professional deformities, for example, using the registration of eye movements. The designed method is sensitive to detect the severity of individual components of the burnout syndrome. Analysis of athletes' eye movements revealed characteristic strategies for responding to components of a stressful situation by avoiding them, which were formed as a response to a high level of experienced professional stress. This is a unique method for assessing

the causes of professional deformities, including burnout syndrome, as well as their further rehabilitation method.

The section **"Interdisciplinary research of the brain: age-related aspect"** tried to answer the questions about brain and cognitive development, including self-motion illusion brain mechanisms (Lomonosov Moscow State University), action development in preterm infant (Uppsala, Sweden), identification of early motor signs in infants with neurodevelopmental disorders (Saint-Petersburg State Pediatric Medical University). Special attention was paid to the interdisciplinary aspects in studying the neurocognitive functions (O. A. Lvova). Brain mechanisms of illusion of a person's own body movement (A. I. Kovalev) and motor development (K. Rossander) of premature babies on neurocognitive functions in the context of ontogenesis (early development, childhood period) were discussed. It was also noted that automation of physical activity measurements using technical means is becoming more common in the pediatric environment, for example, the method of evaluating generalized movements of children. The automation speeds up the decision-making stage for a specialist by pre-analyzing markers that characterize spontaneous movements. As a result, instead of a sequential visual method, it is possible to organize an accelerated inspection with maintaining the quality of the analysis.

The section **"Chronobiological aspects of psychological well-being and cognitive functions"** payed attention to the following research topics: the influence of chronotype on life satisfaction (Perm State University); negative consequences of circadian system dysfunction in schoolchildren and students (Institute of Physiology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences); the effect of sleep-wake regime in feeding behavior (Institute of Physiology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences). There was interesting presentation of Social jetlag (SDL) — a mismatch between biological and social clocks. It was shown that SDL has a number of negative consequences for cognitive functions, well-being, and human health. Most often, SDL is observed among school-age children and students, which leads to a decrease in their ability to adapt to the educational process. Individuals with SDL have lower academic performance and lower levels of nonverbal intelligence. Individuals with SDL have a shorter duration, lower quality and efficiency of sleep. They also consume more high-calorie food and are more likely to consume alcohol.

The section **"Philosophical and methodological perspectives of cognitive research"** was devoted to presentations of the experimental studies that open up new dimensions in the application of techniques due to rethinking of the methodological foundations of psychodiagnostics instruments, including artificial intelligence algorithms, art, and cognitive aspects of emotions: the destructive sides of cognition (Ural Federal University); the influence of modern logic on cognitive methodology (Ural Federal University); the meaning of the complex concept of information for the development of cognitive research (Siberian Federal University). The most important of them were the presentations on the philosophical bases of the cognitive approach. Thus, the talk by professor Bryanik (Ural Federal University) "Alternative methodolo-

gies as the philosophical basis of cognitive psychology: E. Mach and E. Gusserl" provided an insight into the difference between two methodologies. Ernst Mach believed "energy of the senses" and "energy of consciousness" to be a kind of physical energy, adhering to the psychophysical position of explaining psychological phenomena. The views of E. Mach are opposed to the point of view of E. Husserl, who considers phenomenology as a variety of theory and methodology of psychological sciences. Edmund Husserl considered cognitive processes to be pure phenomena rather than physiological mechanisms. Professor Bryanik focused on the fact that cognitive science nowadays corresponds to the presented alternative of positions: on the one hand, we must consider human cognitive processes as a whole phenomenon, and on the other hand, we must take into account the physiological processes that occur in the human body during cognitive activity. The second report was devoted to the phenomenological-hermeneutic approach of Edmund Husserl, but already within the framework of the basis for cognitive processes. Work was presented by professor Zaitseva from Russian Foreign Trade Academy (Moscow). The author reviews Husserl's concept of "analogizing apperception" and suggests using this term as a description of a fundamental cognitive process. Professor Zaitseva pointed that in her earlier research she tried to show the possibility of describing such procedures as categorization and typing through the concept of analogizing apperception, and also the conceptual similarity of the terms analogizing apperception and the amodal completion procedure. Author showed that the using the concept of Husserl's analogizing apperception will expand the possibilities of phenomenological method in the interdisciplinary cognitive research.

The section **"Developmental psychophysiology"** covered issues related to different problems in the area of developmental cognitive neuroscience, including parent interaction with toddlers at risk of autism spectrum disorder (Moscow State Psychological and Pedagogical University); multimodal MRI approaches for investigation of the brain white matter development (National Research University Higher School of Economics); an objective assessment of the child's neurocognitive development as a necessary tool for early rehabilitation (Ural State Medical University). Sergey Kiselev and Irina Galasyuk considered the influence of child-parent relations on the child early neurocognitive development. It was shown that the ability of a parent to show verbal responsiveness determines the communicative abilities of children. This idea can explain a correlation between parental responsiveness and the fact that children at risk for ASD often show a low level of initiation of communication, limited opportunities for responses in communication with an adult, and lack or limited amount of eye contact. The role of the neuropsychologist in the development of child-parent interaction in the process of neuropsychological rehabilitation was considered in the talk of Natalia Sadyrova. In the framework of this section, there was the round-table discussion "Parent-child interaction in child neurocognitive development". In these discussions colleagues from Moscow State Psychological and Pedagogical University and the Ural Federal University presented new collaborative research project for investigating

the influence of parent-child interaction on early child development. The participants discussed first results of these projects.

In the section **"Neurocognitive aspects of personality development in late adulthood"** presenters covered the following topics: the role of reflexivity in personality development at an elderly age (Saint-Petersburg State University); late-life depressions (Lomonosov Moscow State University); personal mobility in late age (Ural Federal University named after the first President of Russia B. N. Yeltsin). There were discussions of the neurocognitive aspects of human development at a late age (E. L. Soldatova, T. B. Sergeeva), of professionalization (E. F. Zeer) and issues of selective attention in normal cognitive aging (D. V. Tatarinov, B. B. Velichkovsky). It was pointed out that a topical issue of psychological science and practice is the search for personal determinants of human activity in old age, preservation of professional health and psychological well-being. Personal mobility, an integrative quality based on individual properties and manifested in the behavior and activities of the subject, is now being investigated as such determinant. In the study of personal mobility in late adulthood, T. B. Sergeeva identified three study vectors: 1) mobility as an individual property, which is the natural «core» of personal mobility; 2) readiness for mobile behavior; 3) mobility as a life strategy.

Young scientists in the different areas of cognitive neuroscience had opportunity to present the results of their researches in the section **"Neurotechnology of future"**. The following reports aroused the great interest: a correlation of diminished working capacity and formal-dynamic properties of individuality; study of the application of virtual reality technologies to learning foreign language; fine motor research in VR.

The II International Forum "Cognitive neuroscience — 2019" contributed to the integration of researches in the field of cognitive neuroscience, pedagogical, developmental psychology, neuropsychology, psychophysiology and medicine. It laid down the foundation for the development of an expert platform in the field of neuroscience at Ural Federal University. Leading experts in the area of cognitive neuroscience discussed the results of their scientific research and outlined new directions for interdisciplinary research. A wide range of researches in the area of cognitive neuroscience was presented. The participants had a good opportunity to see the current level of cognitive neuroscience in Russia and in the world. The Forum created the conditions for development of a new collaborative and cross-cultural research projects and coordinating research protocols.

International Forum on Cognitive Neuroscience in Ekaterinburg is becoming an annual and significant event in the scientific community. The previous Forum "Cognitive neuroscience — 2018" was awarded the Diploma of the nominee of the XX national contest "Golden psyche" in the category "Event of the year in the life of the community".

We invite to participate in the III International Forum "Cognitive neuroscience — 2020", which will be held at Ural Federal University, named after the first President of Russia B. N. Yeltsin in Yekaterinburg in November 2020.

**Special circumstances**

The full text of the materials is presented in S. V. Popova & A. A. Pechenkina (Eds.) (2020). *Cognitive Neuroscience — 2019: Materials of the International Forum*. Yekaterinburg: UrFU.

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**IN MEMORY OF A. R. LURIA**

**ПАМЯТИ А. Р. ЛУРИЯ**

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# Luria in Kisegach. Part 1

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# Лурия в Кисегаче. Часть 1

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The present article is about A. R. Luria's work and life in Kisegach. It is based on his autobiographical book (Luria A. R., 1982; Cole, Levitin, & Luria, 2006 [in Eng.]); on the memories of his daughter, Elena Luria, in her book about her father (Luria E. A., 1994); and on a unique document in the Luria family archive: "The Work Diary. Kisegach, 1942–1943". The general notebook under this name served him for daily records about the examinations of patients and comments on them. This article publishes records entered in the Diary from 19th January until 13th March, 1942.

In the introduction to the publication of "The Work Diary" short biographical material is presented. It gives a description of how A. R. Luria met the beginning of the war, what tasks to create a rehabilitation hospital were assigned to him, how they were carried out. The article presents the memoirs of Luria's daughter Elena (Lena) about the life of their family in Kisegach. It includes the memoirs of B. V. Zeigarnik and S. Ya. Rubinstein on the organization by Luria of labor workshops for the rehabilitation of movements of hand and arms in wounded soldiers. The text is provided with numerous illustrations.

The main part consists of Luria's daily records of patient examinations. Usually he studied from one to four patients. They were patients with aphasia syndromes, with apraxia, agnosia or concussion symptoms. Sometimes Luria gave commentaries to the observed symptoms. He noted the characteristic details of the symptoms and hypothesized the mechanisms of their

occurrence. In general, the Work Diary shows the intense practical and theoretical work of the scientist while working in Kisegach.

***Keywords:*** *Luria's biography; neuropsychology; diagnostics; rehabilitation; aphasia; war trauma; restoration of brain functions.*

Эта статья о работе и жизни А. Р. Лурия в Кисегаче написана по материалам его автобиографической книги (Luria A. R., 1982; англоязычное издание — Cole, Levitin, Luria, 2006), по воспоминаниям о Кисегаче его дочери Елены Лурия в ее книге об отце (Luria E. A., 1994) и по материалам уникального документа, хранящегося в семейном архиве Лурия. Это «Дневник работы. Кисегач, 1942–1943» — общая тетрадь с таким названием служила ученому для ежедневных записей о проведенных исследованиях больных и комментариев к ним. В данной статье впервые публикуются дневниковые записи Лурия с 19 января 1942 г. по 13 марта того же года.

Во введении к публикации дневника даются краткие биографические сведения. Описывается, как А. Р. Лурия встретил начало войны, какие задачи по созданию госпиталя были поставлены перед ним и как он их решал. В статье приведены воспоминания Елены Лурия, дочери ученого, о жизни их семьи в Кисегаче. Также используются воспоминания Б. В. Зейгарник и С. Я. Рубинштейн об организации А. Р. Лурия трудовых мастерских для восстановления у бойцов движений рук. К тексту прилагается 9 фотографий.

Основную часть составляют записи А. Р. Лурия в дневнике об исследованиях больных. Обычно он смотрел от 1 до 4 больных в день. Это были пациенты с синдромами афазии, с симптомами апраксии, агнозии, сотрясения мозга. Иногда Лурия комментировал свои "опыты", он отмечал характерные особенности симптомов и выдвигал гипотезы об их механизмах. В целом дневник является свидетельством интенсивной практической и теоретической работы ученого в госпитале Кисегача.

***Ключевые слова****: биография А. Р. Лурия; нейропсихология; диагностика; афазия; военная травма; восстановление мозговых функций.*

Little Lena Luria was three years old on 21 June, 1941. The war began the next day. Her father, A. R. Luria, wanted to volunteer for the front. He decided to take a photo in the house of his grandparents before parting. This image of 2 July, 1941 was preserved (see *Figure 1*).

However, Luria had to change his plan. In his autobiography, he wrote:

> I was commissioned to organize a rear hospital in the opening months of the war. I chose as the site for our hospital a newly established 400-bed sanitarium in a small village near Chelyabinsk. I organized the construction of laboratories and therapeutic training rooms and recruited a team of former colleagues from Moscow to work with me. Within a month the hospital began its work (Cole, Levitin, & Luria, 2006, p. 139). See *Figure 2*.

As far as Luria recalled, their work in the hospital solved two tasks:

We had to devise methods of diagnosing local brain lesions and of recognizing and treating complications such as inflammation and secondary infection that were caused by the wounds. Second, we had to develop rational, scientifically based techniques for the rehabilitation of destroyed functions (Cole et al., 2006, p. 139).

*Figure 1.* The Lurias. 02.07.1941: himself, his daughter Elena and his wife Lana Lipchina


*Figure 2.* The building of the sanatorium and a plaque about the hospital (modern photo)

A team of 30 people worked in Kisegach under Luria's guidance (see *Figure 3*). Among the psychologists, there were B. Zeigarnik, A. Zaporozhets, S. Rubinstein, E. Bein, and O. Kaufman.

Luria's pre-war studies were a starting point for the development of diagnostic and rehabilitation methods.

Elena Luria[1] wrote in her book:

> The small village of Kisegach lay between two lakes. On the shore of a smaller lake with calm water, overgrown with water plants, there were two two-storied buildings of the sanatorium. In them, they established a hospital without any rebuilding: they made hospital wards and operating theatres… The hospital had the balneary facility built for the sanatorium. After some time, neurophysiological and pathomorphological laboratories were opened, the equipment of which was more than modest… In the basement, where previously there was a billiard room, Alexander Luria set up rehabilitation and labor workshops for wounded soldiers: carpentry, plumbing, sewing, shoe workshops and accounting courses… (Luria E. A., 1994, p. 100).

*Figure 3.* Hospital staff meeting, second left A. R. Luria. From "Going to Visit Luria: A small trip of a Volunteer Group," by Volunteer group of the SUSU "Flame," 2015. Retrieved from https://psyrazv.susu.ru/372-2/. Copyright 2015 by the South Ural State University

[1] E. A. Luria (1938–1992) was a successful research biologist, and a gifted author of children's stories and popular science books. Her book about her father, published in 1994 in a small edition, has long been a bibliographic rarity.

Zeigarnik and Rubinstein (1982) pointed out the difficulty of the tasks Luria faced and the importance of the rehabilitation of patients in the workshops. Sharing their memories, they wrote:

> The working conditions in the hospital were difficult. There was a war going on, and great numbers of wounded persons suffering from a long road were daily delivered to the hospital. And here, in those difficult conditions, Luria deployed not only treatment but also rehabilitation from the very beginning. He selected necessary personnel <…> arranged a room for EEG and therapeutic gymnastics. And the most surprising thing was that large and well-equipped workshops were quickly established under his guidance (Zeigarnik & Rubinstein, 1982, p. 70).

The purpose of the workshops was twofold. The first was to help the soldiers with limited abilities and no profession to perform physical work and become tailors, shoemakers, carpenters, accountants and locksmiths. The second important aim was to rehabilitate the movement of hand and arms. They designed and manufactured special devices in order to hold the tool with injured semi-paralysed hands and arms. Neurologists helped to select which movements were the most effective to the patient. Physiotherapy and physical therapy were used. The wounded persons received a specific labour task during which they performed useful movements. A meaningful work task stimulated patients. In fitting and carpentry shops, they performed most movements with two hands. First, a paretic hand was a "passenger": the work with the tool was performed by a healthy hand. The repetition of such operations during the months led to the inclusion of the paretic hand in the work. The joint efforts of instructors in therapeutic exercise, neurologists and psychologists yielded perfect results. Wounded soldiers acquired labour skills (Zeigarnik & Rubinstein, 1982).

Elena Luria wrote:

> Alexander Luria never went but always ran along the territory of the hospital. He delved into everything; there were no unimportant details to him. Many of those working with him in the hospital told me how Alexander Luria helped them, and did it imperceptibly, on the run. Luria made great efforts so that employees received rations and were not starving…
>
> He participated in receiving wounded persons and carried the soldiers out of the sanitary echelon. Among the soldiers arriving at the hospital, there were Uzbeks and Tajiks who did not speak Russian. Alexander Luria came into the room of soldiers from Central Asia, took a seat on the bed and began speaking in their native language (Luria E. A., 1994, p. 101).

As to the everyday life in Kisegach, Elena Luria wrote:

> We lived in a small wooden house on the hill in Kisegach. A snowy and cold winter came. I sat in the kitchen near the stove and watched Olya (Elena's babysitter living with the Lurias for 60 years) cooking the dinner of dried potatoes. These were shrunken gray-brown disks strung on a thread like dried mushrooms… It was very difficult with food during the first

winter; and then we settled down somehow. We got a kitchen-garden, and my mother and Olya planted potatoes. The mushrooms that we salted for the winter were a great help… (Luria E. A., 1994, p. 112, 135). See *Figure 4*.

Elena recalled:

A lot of snow fell that year snowing hummocks and glades. Roads were covered, and people trampled narrow paths. When the snow was being added the paths became deeper and deeper. And long snow corridors turned out to be on a par with my height (Luria E. A., 1994, p. 112).

Here are Lena's memories about her mother, Lana Pimenovna Lipchina:[2]

When the hospital needed radon for baths, my mother, who first worked as a nurse and then organized a histological laboratory, went to Moscow to get an ampoule with a radioisotope. She drove it on her chest. The train took a long time, stopped often, and my mother reached Kisegach almost in a week. Returning from Moscow, she lost a lot of weight and felt very ill (Luria E. A., 1994, p. 136).

*Figure 4.* The house where the Luria family allegedly lived in 1941–1944 (photo from an album stored in the family archive of Luria)

[2] L. P. Lipchina (1904–1978) became A. R. Luria's wife in 1933, got her PhD in 1937 and DSc in biology in 1954. At the end of 1938, she began working in the Institute of Neurosurgery where she gathered a group to cultivate brain tumors beyond the organism. On returning from Kisegach, she went on working at cultivating tumor-tissue cultures.

Much later, she understood that she had been exposed to radiation and had suffered radiation disease. Only owing to her strong organism and resistance, she could return to work in the hospital and continue living and working actively (see *Figure 5, 6*).

*Figure 5.* The Lurias near the house in the village of Kisegach

*Figure 6.* Alexander Luria and Lana Lipchina in Kisegach

Radon revealed itself many years later. In 1977, Lana Lipchina was diagnosed with cancer. She was hospitalized and operated on; she had cancer with metastases. Her diagnosis was hidden from Luria. But one day, having come to his wife in the hospital, and awaiting an appointment with the doctor, Luria saw his wife's medical history and read the diagnosis. It was soon after July 16, when his friends and colleagues congratulated him on his 75th birthday. After Lana's discharge from the hospital, the couple went to the Uzkoe sanatorium near Moscow. In the evening of 14th August, Alexander Romanovich went down to the lobby to call one of his acquaintances and ask them to help him get a rare medicine for Lana Lipchina. In the phone booth, he felt sick and fell down. The doctor on duty could not help. A. R. Luria died of cardiac arrest. On his desk in the hotel room, there remained the unfinished "Paradoxes of Memory".

Lana Lipchina outlived her husband by five months.

Let us get back to Kisegach (see *Figure 7*). According to Zeigarnik and Rubinstein, A. R. Luria and the commissar of the Hospital Chekalin managed "to create an exemplary medical rehabilitation institution in difficult conditions" (Zeigarnik, Rubinstein, 1982, p. 71). Luria worked not only with patients within the framework of the neuropsychological research and rehabilitation but also he organized scientific conferences and released manuals that were distributed among other hospitals. In the list of his papers, there were four articles that dated back to 1942–1943 on the rehabilitation of functions (Luria A. R., 2003). These were the only articles that appeared in the main press in neurological journals.

*Figure 7.* The Lurias and an unknown person

Luria edited the text of the book "Temporal (Sensory) Aphasia" which he prepared for his doctoral thesis in medicine. This was the first volume of "The Study of Aphasia From the Point of View of Brain Pathology" written in 1940; the second volume was about semantic aphasia. Both volumes remain unpublished (Luria A. R., 1940). The second book was described by T. V. Akhutina and A. R. Agris (2018).

In Kisegach, Luria prepared the manuscript of the book "Essays on the Theory of Traumatic Aphasias" (Luria A. R., 1943). This book has been preserved in the family archive as well. It has 138 typewritten pages. The title page reads: "Rehabilitation Branch of the Neurological Clinic of the All-Union Institute of Experimental Medicine. Neurosurgical Rehabilitation Hospital of the All-Union Central Council of Trade Unions". The author's name and the title "Essays on the Theory of Traumatic Aphasias" appear below, with "Kisegach 1943" at the bottom.

The book has three sections. The first two sections are very similar to the text of Part One of "Traumatic Aphasia", Chapters I and II. The third section corresponds to the sections of Part Two, Chapters III–VII. Thus, "Essays" are a draft of "Traumatic Aphasia". The date of 14th August, 1943 is shown on the last page of the Essays. This draft book and two volumes written in 1940 require a thorough analysis to identify the path to the classic description of aphasia syndromes, outlined in "Traumatic Aphasia".

## The Work Diary

"The Work Diary. Kisegach, 1942–1943" is kept in the family archive. Elena Luria said that her father "never threw away a single piece of paper in his life". Of course, this is an exaggeration, but he did indeed leave a very large archive. The oldest part includes records of the investigations of speech in the 1920s, records from the Central Asian expedition, and many other documents, which are kept at their dacha in the village of Svistukha (The Moscow Region). The main part is in Moscow with Elena Georgievna Radkovskaya, the grandniece of A. R. Luria, who is the keeper of the archive. A small part of the archive, preserved by Professor E. D. Khomskaya, Luria's closest co-worker, is now on the premises of the Laboratory of Neuropsychology, Faculty of Psychology, Lomonosov Moscow State University (the keeper is T. V. Akhutina). The faculty archive contains more than 10,000 pages of material from the 1920s to the 1970s that incorporate nearly the entire research activity of the famous scientist. In 2016–2017, the documents of this part of the archive were converted into an electronic form. They will soon be available on the archive's website.

"The Work Diary" is a 48-sheet notebook without any page numbering. As a rule, the text is on the left page, and the right one is for comments. The same arrangement of material is used by A. N. Leontiev. The notes of Vygotsky's talks on "The Problem of Consciousness" are outlined in the same way (Vygotsky, 1997). In the text below, comments from the right pages appear immediately after the records to which they relate. There are many abbreviations in the text; all of the abbreviations are expanded in this publication. In obvious cases they are not specifically marked, but in the most difficult places the dis-

closure is given in [square] brackets. Illegible words are marked with <angle> brackets, and inserted words are in {curly} brackets. All of the author's underlines are preserved; a single underline is conveyed respectively, double underscores are passed in bold with underscores.

The diary covered the period from 19th January, 1942 until 22nd July, 1943. In 1942, 74 entries were made, with 30 of them presented in this publication. Luria left for Moscow in late April and returned to Kisegach on 12 May (based on the letter to Sergey Eisenstein of 11th May, published in Elena Luria's book, 1994). Diary entries resume in mid-June. At the end of July, Luria went to Kazan. There were no records in December, 1942. There were 67 entries in 1943; most of them were made between January and April. In May, there was one record: "Preparation for a dissertation, preparing for a conference". This entry is very important. The Internet has links to 1942, 1943, and 1944 as years of defense of the dissertation. The English edition of the book by E. D. Homskaya, "Alexander Romanovich Luria. A Scientific Biography" specified 1944 (Homskaya, 2001), and Wikipedia specifies 1943. Provided this, one might think that the defense took place in 1943. It is most likely that the higher attestation commission approved it in 1944.

The diary entries ended on 22 July, 1943, but Luria went on working at the hospital. He returned to Moscow in October of 1944, continuing to run the hospital until November, 1944.

Let us attend to the Diary. The cover and a page of the diary are shown in *Figure 8* and *Figure 9*. The Russian text of the Diary is presented in the Appendix.

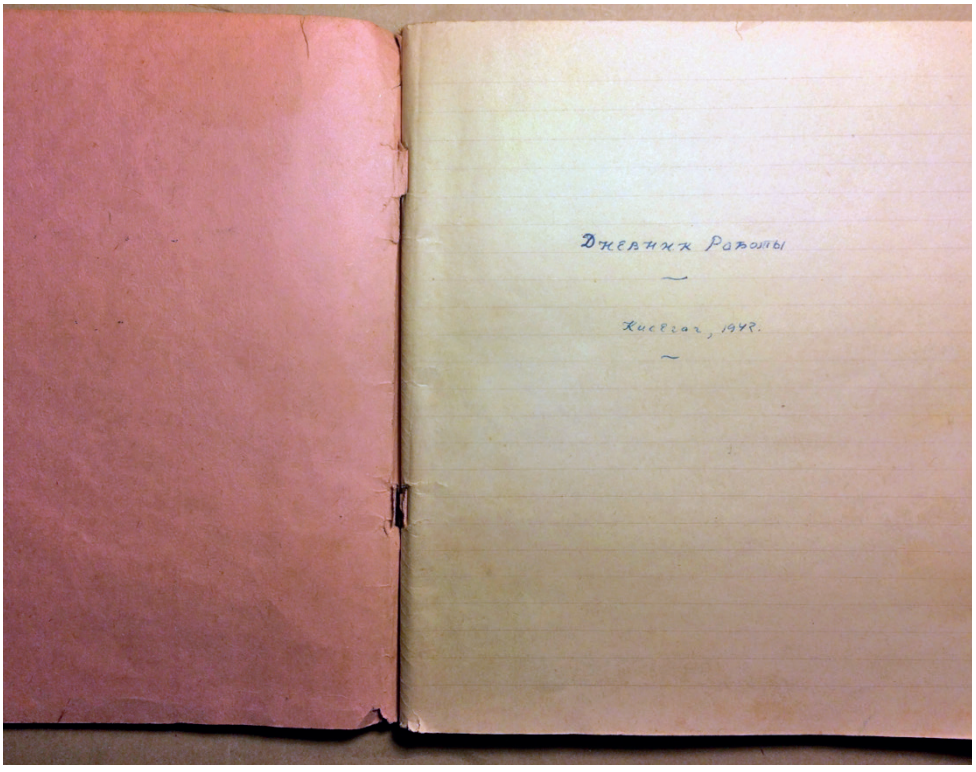


*Figure 8.* The cover of "The Work Diary"

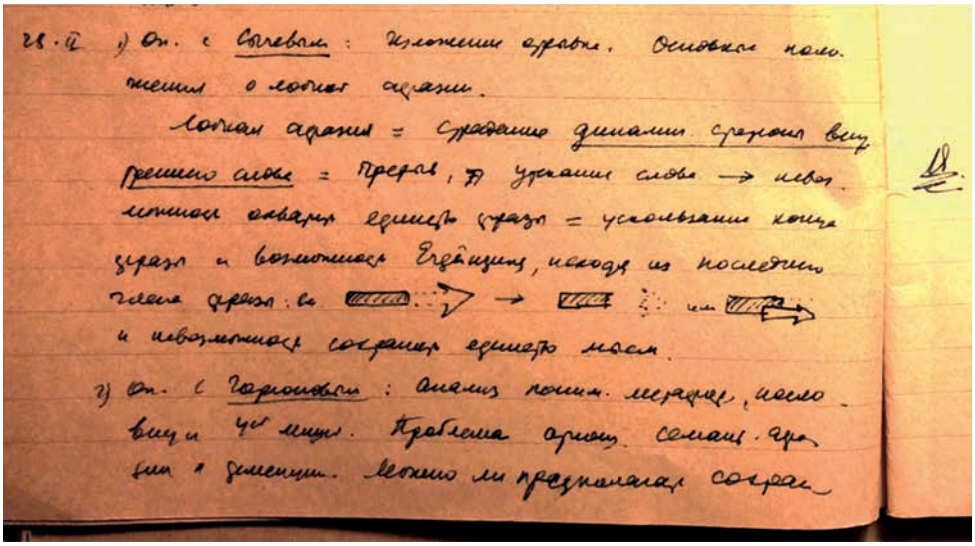

*Figure 9.* A fragment of one of the pages of the "Diary" with an entry dated 28.02.1942

## The Work Diary

**19.I.42**

The discussion of experiments with a concussion patient[3] (Dekhterev).

a) The mystery of slowness; deciphering the slowness as a result of systemic disintegration, and hence → voluntarizing[4] {making something voluntary} all the components.

b) Memory: the flow-away of the traces of memory! the interweaving of any components in amnestic terms (the experience with the reproduction of the tale, [interlaced] by other ff {functions}).

c) Preservation of the logical components.

**20.I.42**

Temporal aphasia: Chusovitin. Severe temporal syndrome. The generation of paraphasias because of the non-retention of verbal images (fuzziness of <Bereiche>[5]),

— a test for repeating [double] words

(Planning the Bein's[6] theme {of her scientific work}).

[3] Concussion syndrome is a set of general brain symptoms caused by mechanical trauma to the brain.

[4] The author's neologism.

[5] See entry from 9.II.42 and footnote 11.

[6] E. S. Bein — a well-known psychologist-aphasiologist and a staff member of the hospital, who defended her dissertation on sensory aphasia. In "Traumatic Aphasia", Luria refers to her research 11 times.

**21.I.42**

A trial with Soskov: (1) Pseudo-semantic disorders (materials to separate temporal-aphasic from semantic disorders (semantic disorders in the non-retention of verbal images — [cf.] a primary preservation of semantic relations, the state of intelligence).

(2) The preservation of narrative speech.

*On the right side*: The trial on narrative speech:

{it is} impaired in frontal aphasias (cf. a sharp dissociation of reactive {responsive} and narrative speech in Svetlov, etc.);

{it is preserved} — in temporal and parietal impairments (this type of dissociation is absent: cf. [Gtevich], Soskov, etc.)

**22.I.42**

The experiment with Usatov: Motor Skills: A typical example of subcortical motor impairments: disturbances of motor postures + dysmetria + positional apraxia but all types of voluntarily organized movements are preserved.

NB: Injury temple-subcortex → premotor movements are good!!

*On the right side*: NB: Motor Skills:

1. Premotor disturbance (pure) — no kinetic melodies, schemes…
2. Premotor-subcortical impairment — no kinetic schemes + excessive movements (cf. Nurmukhanov, cf. Alipov!).
3. Pure subcortical {impairment}

(temporal subcortical [impairment] → positional disturbances, no excessive movements)

(cf. temporal access {during the operations} the group!: Fedorov, Usatov!)

**23.I.42**

Experiment with Fedorov (pure temporal-subcortical syndrome)

(1) The absence of aphasia in the left anterior-subcortical region

(2) An entire preservation of the structure of intellectual operations with its dynamics disturbance (Sperrung[7] <3 letters illegibly>)

(3) Mnestic disintegration — of knowledge (the rest of concussion syndrome!)

(4) The development of quantitative tests for exhaustion.

*On the right side*: Compare negative cases of temporal lesions

Fedorov: anterior-temporal syndrome: only amnestic components in the voluntary speech in the absence of amnesia in naming = the deactivation of speech: the disturbance of the unity of thinking-speech (**dynamics**).

**24.I.42**

(1) Experiment with Blinnikov: an Example of a functional protragated[8] aphasic syndrome!! **NB**!

*On the right side:* **NB:** functional protragated aphasia!

---

[7] Die Sperrung (Ger.) — blocking.

[8] Protragated — protracted.

(2) The development of a brief scheme of the examination of patients with concussion (with Zeigarnik).[9]

**9.II.42**

Analysis of Bashinsky. 1) Frontal syndrome of thought disorder: the disorder of thinking activity: the intent, the creation of a mental Bereich[10] and "casting a fishing rod in the future".

A frontal patient is unable to create the PROBLEM (i. e., an empty Bereich which coordinates the relevant reasoning, and to which the reasoning flow is equalized); it is impossible for him to experience an error, a genuine act of control and so on. Everything is replaced by Kurzschluss'es[11] and thought flow by the type of Ergänzung[12] to the whole;

Both topic and a dialogue are impossible for him.

*On the right side*: **NB**: Dialogue as a method of bringing out the inner dialectic of the patient!

**10.II.**

Experiment with Duriagin: the subcortical suffering of thinking: it is based on de-automatization, "thinking not immediately" but all the complex forms of intellectual processes are entirely preserved, primary memory and primary volitional set are preserved.

**11.II.**

1) Experiment with Usaykov. Specific features in thinking in subcortical lesions: impairments in the first link — grasping: [here] the clarity of the structure is replaced by contamination, and hence it is built on dream-based mechanisms, the further flow of thinking is quite possible
2) Experiment with Menshik: a clear frontal syndrome of stereotypes

NB: 100 — 2: 89 — 83, 79 — 73, 69 — 63

*On the right side*: NB

**12.II.**

1) The analysis of Kadashev. A clear syndrome of basal frontal lobe: a complete loss of affective generalization!

*On the right side:* the disintegration of affective generalization!

2) Experiment with Belov: one more subcortical frontal syndrome (slowness, [no attitude]).

*On the right side:* NB: Fedorov et al.

**16.II.**

1) Experiment with Kondratiev and Shevchenko: the right frontal lobe [gives] invariably a failure in the perception of rhythms despite the ability to perform that.

---

[9] B. W. Zeigarnik (1900–1988) is a famous pathopsychologist, a student of K. Levin and L. S. Vygotsky, she was a staff member of the hospital.

[10] Der Bereich (Ger.) — region, field, i. e. Luria means the activation of a semantic zone, fixing the content of the future statement / plan of activity.

[11] Der Kurzschluss (Ger.) — electrical short, in the figurative sense — impulsive guess.

[12] Die Ergänzung (Ger.) — addition.

*On the right side*: **NB**: The right frontal lobe = operating the time.

2) Experiment with Shevchenko: the patient once developed a stereotype after reading the fragment ("one owner had a hen that laid three eggs"[13]). He not only retained this stamp for 3 weeks and after a single reading gave it 3 weeks later, — but was unable to succumb to retraining, and — even after repeated reading explaining the error — still continuing to give it!!

*On the right side*: **NB**

3) Experiment with Sychev (the left frontal lobe). A clear definition of the frontal defect of intelligence:

a) The disruption of the normal relations of thought and speech: "The language goes ahead of thought", and his slips of the tongue by type of insertion are "slips of inattention".

*On the right side*: **NB: To the frontal** aphasia!! (not Broca's but the aphasia of frontal impairments of the unity of thought and speech).

b) The disturbance of thinking is not in the cognitive operation itself (for instance, counting) but in the inability to keep the conditions in memory.

Again, here is a peculiar defect of memory for thoughts — both the memory itself and intelligence itself are entirely preserved (compare: a complete preservation of tests for memorizing words).

**17.II.**

1) Experiment with Usatov. The disturbance of thinking is in the disturbance of direction, set.

2) Experiment with major Novitsky: with a relative general safety — the disturbance in the performance of rhythms.

*On the right side*: Compare: the right frontal lobe!!

**18.II.**

Experiment with Sizikov. A concussion patient may have no premotor impairments!

**24–25.II.**

Experiment with Goryunov. A pure semantic aphasia (= the impossibility to Zusammensehen[14] semantic structures!).

**26.II.**

1) Experiment with Goryunov. Typical problems, hesitations of a semantic aphasic patient ("more light = less light", etc.).

2) Experiment with Sychev — the Inability to turn from the plan to a coherent description, narration.

*On the right side*: The plan of **frontal aphasia**.

3) Experiment with Usatov. Primary amnesia in subcortical ailment.

[13] A. R. Luria usually told the patients the story: "One owner had a chicken laying golden eggs. He wanted more gold and killed the chicken. But there was no gold inside". The patient replaces the words "golden eggs" with "three eggs". Then he repeats these words stereotypically.

[14] Zusammensehen (Ger.) — here and hereinafter, simultaneous vision.

**27.II.**

Experiment with Goryunov. The analysis of the structure of the phrase (Passive voice) "The sun is illuminated by the earth". The mechanism of the assessment of the phrase is a mechanism of practical words placement and the recognition of the right meaning. The analysis, comprehension of sense is impossible.

**28.II.**

1) Experiment with Sychev: the narration of the fragment. The main statements of frontal aphasia.

Frontal aphasia = suffering of the dynamic side of the inner word = The interruption, flow-away[15] of the word → the inability to embrace the unity of the phrase = the elusion of the end of the phrase, and the possibility of Ergänzung based on the last part of the phrase: see ▪▪▪▪ ====> → ▪▪▪▪· · -> or ▪▪▪▪ ═══>
and the inability to maintain the unity of thought (*see the scheme of Luria in Figure 9*).

*On the right side*: **NB**

2) Experiment with Goryunov: The analysis of the understanding of metaphors, proverbs and the Odd one out test. The problem of the relationship of semantic aphasia to dementia. May one expect that categorical thinking is preserved in the disturbed Zusammensehen??
3) Experiment with Goryunov: a test that reveals the feature of patients' reactions/responses to a long-term work.

**2.III.1942**

Experiment with Goryunov: 1) The ability to grasp the relations of generality!! 2) The preservation of general ideas — with amnesia for them — and when slipping into a particular plan!

*On the right side*: curly bracket to 1) and 2) NB!

**4.III.42**

1) Experiment with Karabanov (premotor aphasia) 1) a pure form of de-automatization; 2) a disturbed grasping "not immediately".

*On the right side*: NB: One of the main phenomena: **de-automatization of grasping!** (a dynamic impairment of intellectual [processes])!!

2) Experiment with Goryunov: the dynamics of concepts: the possibility of comparison and generalization — but the trend toward slipping into the plan of complex thinking.

**6.III.42**

1) Experiment with Goryunov. Analogies. The ability to master the analogy and transfer! Secondary difficulties are in this.
2) Usatov. Difficulties in memorization (the primary memory impairment — memorizing a meaningful text is easier than memorizing a poem).

[15] The author's neologism.

**7.III.42**

Experiment with Goryunov. Counting. The inability to immediately evaluate a multi-digit number. Grasping a multi-digit number (a) by a visual analogy or (b) by means of superimposing an external grid.

**7.III.**

The scheme of frontal aphasias[16]

---

Broca's Aphasia
(its close inverse relationship with Wernicke's area.
Sound agraphia at <testing>
its close feedback to the parietal zone:
semantic disturbances at <testing>) Shcherbakov!

Premotor Aphasia
Speech de-automatization, [motor], [grasp]
The denervation impairment of writing, Merskalov,
a relative preservation of thought Karabanov

Frontal Aphasia (or Para-aphasic state)
(the disruption of the relationship of thought with speech — inner speech. Sychev
Tearing thread of thought,
Disturbance of narration, storytelling, dynamics of Aussage[17] and Propositional speech[18])

---

**11.III.42**

1) Experiment with Goryunov. Counting: The difficulty is not in the concept of number, digit, sign, — but in grasping the number, combining its components in operations (especially in mind).
2) Experiment with Karabanov: a) The sharpest aspontaneity of speech — the inability to proceed from the internal plan, the inability for a narrative speech

b) The availability of "Ergänzungsfragen" (direct questions) and the unavailability of indirect questions (requiring a layer of thinking)

*On the right side*:

NB: direct questions (Ergänzungsfragen[19]) + cf. average child

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[16] The proposed classification of frontal aphasias differs from the previous and subsequent ones. Here, under the name of frontal aphasia, dynamic aphasia is introduced. "Premotor" aphasia is described in "Traumatic Aphasia" as "speech disorders in the lesion of the "marginal" zones of the premotor region" (Luria A. R., 1970; see also Akhutina, 2016).

[17] Die Aussage (Ger.) — statement.

[18] Propositional speech (Eng.) — from proposition, statement, that is, predicative narrative speech. Luria quoted the H. Jackson's (1868, 1869/1932) statement "To speak is to propositionize" (Luria A. R., 1976, p. 37).

[19] Ergänzungsfragen (Ger.) — questions that require additions. In "Traumatic Aphasia" Luria distinguishes two types of questions in dialogic speech. Some do not require any search for new formulations ("Did you have lunch today?" "Can you read?"); others (for instance, "How were you injured?") require the patient "to show a special activity in finding new formulations" (Luria A. R., 1970).

indirect questions (requiring — age 2–2,5 years
a layer of **thinking**!)

**12–13.III.42**

1) Experiment with Moiseyev: A severe parietal and temporal aphasia
2) Gdevich (Kaufman {O. P. Kaufman}) — an entire preservation of rhythms.
*On the right side*: NB!!!
3) Experiment with Karabanov: A gross violation of the expounding (narrative) speech; disorder of active forms; disorder of grasping.

***To be continued***

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## Appendix
## Приложение

Это приложение мы решили дать, поскольку текст «Дневника работы» представляет собой личные записи. В какой-то мере эти записи — вынесенная вовне внутренняя речь. Перевод такого текста на иностранный язык не исключает возможность субъективной интерпретации написанного. Чтобы избежать этого риска и позволить читателям самим ознакомиться с первоисточником, в приложении мы публикуем записи на языке оригинала. В тексте «Дневника» содержатся сокращения. Их объяснение дано в квадратных скобках. Неразборчивые слова заключены в угловые скобки, а вставленные слова — в фигурные скобки.

### Дневник работы[1]

**19.I.42**

Обсуждение опытов с коммоционным[2] больным (Дехтерев).

a) Тайна замедленности; расшифровка замедленности как результата системного распада, и отсюда → опроизвольнение всех компонентов.

b) Память: уплывание следов! вплетение любых компонентов мнестического плана (опыт с воспроизведением рассказа, [прослоенного] другими ff {функциями}).

c) Сохранность логических компонентов.

**20.I.42**

Височная афазия: Чусовитин. Грубый височный синдром. Рождение парафазий из неудержания словесных образов (нечеткость < Bereich'ов>[3])

— опыт с повторением [двойных] слов

(планирование темы Бейн[4]).

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[1] Обложка и страница из «Дневника» представлены на рис. 8 и 9 (с. 180–181).

[2] Коммоционный синдром — совокупность общемозговых симптомов, вызванных механической травмой головного мозга.

[3] Bereich (нем.) — зона, область. См. запись от 9.II.42 и сноску 9.

[4] Э. С. Бейн — известный психолог-афазиолог, сотрудник госпиталя, защитила диссертацию о сенсорной афазии. В «Травматической афазии» Лурия ссылается на ее исследования 11 раз.

**21.I.42**

Опыт с Сосковым: (1) Псевдо-семантические расстройства (материалы к отграничению височно-афазических от семантических нарушений (семантические расстройства при неудержании словесных образов — [ср.] первичная сохранность смысловых отношений, состояния интеллекта).

(2) Сохранность повествовательной речи.

*На правой стороне*: Опыт на повествовательную речь:

нарушена при лобных афазиях (ср. резкую диссоциацию реактивной и повествовательной речи у Светлова и др.);

сохранна — при височных и теменных расстройствах (этой диссоциации нет: ср. [Гтевич], Сосков и др.)

**22.I.42**

Опыт с Усатовым: Моторика: Типичный пример подкорковых нарушений моторики: нарушение двигательных поз + дизметрия + позиционная апраксия — при сохранности всех видов произвольно-организованных движений.

NB: Ранение висок-подкорка → движения премоторного типа идут хорошо!!

*На правой стороне*: NB: **Моторика**:

1. Премоторное нарушение (чистое) — нет кинетических мелодий, схем…

2. Премоторно-подкорковое нарушение — нет кинетических схем + лишние движения (ср. Нурмуханов, ср. Алипов!).

3. Чистое подкорковое

(височное подкорковое [нарушение] → позиционные нарушения, лишних движений нет)

(ср. височные подходы группа!: Федоров, Усатов!)

**23.I.42**

Опыт с Федоровым (чистый височно-подкорковый синдром)

(1) Отсутствие афазии при <поражении> левой передне-подкорковой области

(2) Полная сохранность структуры интеллектуальных операций при нарушении ее динамики (Sperrung[5] <3 буквы нрзб>)

(3) Мнестический распад — знаний (остатки коммоционного синдрома!)

(4) Разработка количественных проб на истощаемость.

*На правой стороне*: Сравни отрицательные случаи височных поражений

Федоров: передне-височный синдром: только амнестические компоненты в произвольной речи при отсутствии амнезии в назывании = деактивация речи: нарушение единства мышления/ речь (**динамика**).

[5] Sperrung (нем.) — блокирование.

**24.I.42**

(1) Опыт с Блинниковым: Пример функционально-протрагированного[6] афазического синдрома!! **NB**!

*На правой стороне:* функционально-протрагированная афазия!

(2) Разработка краткой схемы исследования коммоционных больных (с Зейгарник)[7].

**9.II.42**

Разбор Башинского. 1) Лобный синдром нарушения мышления: нарушение деятельности мышления: замысел, создание мысленного Bereich'a[8], «закидывание удочки в будущее».

У лобного больного невозможно создание Проблемы (т. е. пустого Bereich'a, который координирует соответствующие рассуждения, к которому подравнивается течение рассуждения); у него невозможно и переживание ошибки, подлинный акт проверки и т. д. Все заменяется Kurzschluss'ами[9] и течением мысли по типу "Ergänzung"[10] до целого;

У него невозможна и тема, и диалог.

*На правой стороне*: NB: Диалог как метод вынесения наружу внутренней диалектики больного!

**10.II.**

Опыт с Дурягиным: Подкорковое страдание мышления: оно построено по типу дезавтоматизации, «мышление не сразу», но при полной сохранности всех сложных форм интеллектуальных процессов, при сохранности первичной памяти и первичной волевой установки.

**11.II.**

1) Опыт с Усайковым. Особенности в мышлении при подкорковых поражениях: нарушения в первом звене — схватывании: [здесь] четкость структуры заменяется контаминацией и поэтому строится по сновидным механизмам; дальнейшее течение мышления вполне возможно
2) Опыт с Меньшиком: ясный лобный синдром штампов

**NB**: 100–2: 89–83, 79–73, 69–63

*На правой стороне*: NB

**12.II.**

1) Разбор Кадашева. Ясный синдром базальной лобной доли: полное выпадение аффективного обобщения!

*На правой стороне*: распад аффективного обобщения!

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[6] Протрагированный — затяжной.

[7] Б. В. Зейгарник (1900–1988) — всемирно известный патопсихолог, ученица К. Левина и Л. С. Выготского, сотрудник госпиталя.

[8] Bereich (нем.) — зона, область, т. е. Лурия имеет в виду выделение смысловой зоны, фиксирующей содержание будущего высказывания /плана деятельности.

[9] Kurzschluss (нем.) — короткое замыкание, переносное значение — импульсивная догадка.

[10] Ergänzung (нем.) — дополнение.

2) Опыт с Беловым: еще подкорковый лобный синдром (замедленность, [отсутствие отношения]).

*На правой стороне*: Федоров и др.

**16.II.**

1) Опыт с Кондратьевым и Шевченко: Правая лобная доля [дает] неизменно нарушение оценки ритмов при возможности их выполнения.

*На правой стороне*: NB. Правая лобная доля = организация **времени**.

2) Опыт с Шевченко: Больной, раз выработавши штамп при чтении отрывка («У одного хозяина была курица, которая несла по трое яиц»[11]), не только сохранил этот штамп в течение 3-х недель и после однократного чтения дал его через 3 недели, — но оказался не в состоянии поддаться переобучению, и — даже после повторного чтения с разъяснением ошибки — все же продолжал давать ее!!

3) Опыт с Сычевым (левая лобная доля). Четкая формулировка лобного дефекта интеллекта:

a) Нарушение нормальных соотношений мысли и речи: «язык идет впереди мысли», а его оговорки вплетения — «оговорки невнимания».

*На правой стороне*: NB: К **лобной** афазии!! (не Брока, а афазия лобных нарушений единства мысли и речи).

b) Нарушение мышления не в самой мыслительной операции (например, счета), а в невозможности удержать условия в памяти.

Здесь — снова своеобразный дефект памяти на мысли — при полной сохранности и самой памяти и самого интеллекта (сравни: полная сохранность опытов на запоминание слов).

**17. II**

1) Опыт с Усатовым. Нарушение мышления — в нарушении направленности

2) Опыт с майором Новицким: При относительной сохранности — нарушение в исполнении ритмов.

*На правой стороне*: Сравни: правая лобная доля!!

**18. II.**

Опыт с Сизиковым. Коммоционный больной может и не давать нарушений премоторного типа!

**24–25.II.**

Опыт с Горюновым. Чистая семантическая афазия (=невозможность Zusammensehen[12] семантических структур!).

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[11] А. Р. Лурия обычно рассказывал больным историю: «У одного хозяина курица несла золотые яйца. Он захотел побольше золота и зарезал курицу. А внутри золота не было». Больной заменяет слова «золотые яйца» на «трое яиц». Далее он эти слова стереотипно повторяет.

[12] Zusammensehen (нем.) — здесь и далее симультанное видение.

**26.II.**

1) Опыт с Горюновым. Типичные конфликты, колебания семантического афазика («более светлый = менее светлый» и т. д.)

2) Опыт с Сычевым — Невозможность перейти от плана к связному изложению, повествованию.

*На правой стороне*: План **лобной афазии.**

3) Опыт с Усатовым. Первичная амнезия при подкорковом страдании.

**27.II.**

Опыт с Горюновым. Анализ строения фразы (страдательный залог) «Солнце освещается землей». Механизм оценки фразы есть механизм практического размещения слов и узнавание правильного смысла. Анализ, осознание смысла невозможен.

**28.II.**

1) Опыт с Сычевым: Изложение отрывка. Основные положения о лобной афазии.

Лобная афазия = страдание динамической стороны внутреннего слова = прерывание, утекание слова → невозможность охватить единство фразы = ускользание конца фразы и возможность Ergänzung, исходя из последнего члена фразы: см. ▪▪▪▪ ====> → ▪▪▪▪· · ·> или ▪▪▪▪ ≡≡≡≡≡>

и невозможность сохранить единство мысли (*см. схему Лурия на рис. 9, с. 181*).

*На правой стороне*: **NB**

2) Опыт с Горюновым: Анализ понимания метафор, пословиц и 4-й лишний. Проблема отношения семантической афазии к деменции. Можно ли предполагать сохранное категориальное мышление при нарушении Zusammensehen??

3) Опыт с Горюновым: тест, вскрывающий особенность реакций больных на длительную работу.

**2.III.1942**

Опыт с Горюновым: 1) Возможность схватывать отношения общности!! 2) Сохранность общих понятий — при амнезии на них — и при соскальзывании в конкретный план!

*На правой стороне*: фигурная скобка к 1) и 2) **NB**!

**4.III.42**

1) Опыт с Карабановым (премоторная афазия) 1) чистая форма дезавтоматизации; 2) нарушение схватывания «не сразу».

*На правой стороне*: NB: Один из основных феноменов: дезавтоматизация схватывания! (динамическое нарушение интеллектуальных [процессов])!!

2) Опыт с Горюновым: динамика понятий: возможность сравнения, обобщения — но тенденция к соскальзыванию в план комплексного мышления.

**6.III.42**

1) Опыт с Горюновым. Аналогии. Возможность овладения аналогией и переносом! Вторичные трудности в этом.
2) Усатов. Трудности заучивания (первичное нарушение памяти — заучивание осмысленного текста легче, чем заучивание стихотворения).

**7.III.42**

Опыт с Горюновым. Счет. Невозможность сразу же оценить многозначное число. Схватывание многозначного числа (a) по наглядной аналогии или (b) путем наложения внешней сетки.

**7.III.**

Схема лобных афазий[13]

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Афазия Брока
(ее тесная обратная связь с зоной Вернике. Щербаков!
Звуковая аграфия при <исследовании>
ее тесная обратная связь с теменной зоной:
семантические расстройства при <исследовании>)

**Премоторная афазия**
Дезавтоматизация речи, [мотор.], [схватыв.] Мерскалов,
денервационное нарушение письма, Карабанов
относительная сохранность мысли

**Лобная афазия** (или пара-афазическое состояние)
(нарушение связи мысли с речью — внутренней речи. Сычев
Рвущаяся нить мысли.
Нарушение повествования, изложения, динамики Aussage[14] и Propositional speech[15])

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**11.III.42**

1) Опыт с Горюновым. Счет: Трудности не в понятии числа, разряда, знака, — а в схватывании числа, совмещении его компонентов при операциях (особенно в уме).

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[13] Данная классификация лобных афазий отличается от предыдущих и последующих. Здесь под «лобной афазией» понимается динамическая афазия. «Премоторная» афазия описывается в «Травматической афазии» как «нарушения речи при поражении “пограничных” разделов премоторной зоны» (Luria A. R., 1970, pp. 176–185; см. также: Akhutina, 2016).

[14] Aussage (нем.) — высказывание.

[15] Propositional speech (англ.), от proposition — предложение, утверждение, т. е. предикативная повествовательная речь. Лурия цитирует положение Джексона (Jackson, 1868, 1869/1932) “To speak is to propositionize” (Luria A. R., 1976, p. 37).

2) Опыт с Карабановым: a) Резчайшая аспонтанность речи — невозможность исходить из внутреннего плана, невозможность повествовательной речи

b) Доступность «Ergänzungsfragen»[16] (прямых вопросов) и недоступность косвенных вопросов (требующих прослойки мысли)

*На правой стороне*:

NB: прямые вопросы (Ergänzungsfragen) + ср. детский
косвенные вопросы (требующие — возраст 2–2,5 года
прослойки **мысли**!)

**12.–13.III.42**

1) Опыт с Моисеевым: Грубая теменная и височная афазия

2) Гдевич (Кауфман {О. П. Кауфман}) — полная сохранность ритмов.

*На правой стороне*: NB!!!

3) Опыт с Карабановым: Грубое нарушение излагающей (повествовательной) речи; нарушение активных форм; нарушение схватывания.

***Продолжение следует***

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[16] Ergänzungsfragen (нем.) — вопросы, требующие дополнения. В «Травматической афазии» Лурия различает два типа вопросов в диалоге, одни не требуют поиска новых формулировок («Ты сегодня обедал?», «Ты умеешь читать?»), другие, например, «Как ты был ранен?», требуют от больного «проявить специальную активность в нахождении новых формулировок» (Luria A. R., 1970, pp. 299–300).

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