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FROM THE GUEST EDITOR

It is a great honor to serve as Guest Editor for this third issue of Acta Neuropsychologica in 2013 entitled: **Impact of Luria's procedure on contemporary neuropsychological studies** which includes selected papers from "The Moscow International Congress dedicated to the 110th anniversary of Alexander Romanovich Luria's birth" organized by the Lomonosov Moscow State University, Department of Psychology, the Burdenko Neurosurgery Institute, the Russian Academy of Education and the Russian Psychological Society, which was held on 28th November – 1st December 2012".

Alexander Romanovich Luria (1902-1977), Russian psychologist and neuropsychologist, is recognized throughout the world as one of the most eminent and influential psychologists of the 20th century, who made advances in many areas, including cognitive psychology, the processes of learning and forgetting, mental retardation and neuropsychology.

Fig. 1. Alexander Romanovich Łuria (1902-1977): Post war portrait (1940s)
Source: Pachalska & Kaczmarek 2012 [1]

Luria's scientific career was built in "the stages of a journey undertaken" (as the Russian title of Luria's autobiography says): co-working with Lev S. Vygotsky (1896-1934) and the foundation of the cultural-historical school (the 1920s), cross-cultural research, an expedition to Central Asia, and studies on twins (the 1930s), the war and the first works on brain injured patients (the 1940s), research into mentally retarded children, brain injuries and rehabilitation (1950s), the systematic development of neuropsychological research (the 1960s and 70s). The research on the functioning of the brain, touching

on learning and forgetting, attention and perception as psychological constructs, was to engage Luria for forty years. Analysis of functional changes resulting from local brain lesions constituted the area of greatest interest. The single-case approach to neurological studies was to be the focus of his last years (Pachalska & Kaczmarek 2012).

During 2012, the 110th anniversary of his birth, a number of congresses were organized in his honor. The Moscow International Congress dedicated to the 110th anniversary of Alexander Romanovich Luria's birth was one of the main events incorporating a wide variety of contributions. Each speaker pointed out some aspect of Luria's work, familiar as student or co-worker, neuropsychologist or as historian of psychology or culture. Despite the variety of topics presented, only a part of his vast and complex scientific activity was taken into account.

Given the influence of his work on so many topics, we have decided to discuss in this Acta Neuropsychologica selected papers presented during this event. We attempt to show the impact of his approach on the foundations of microgenesis to the diagnosis and rehabilitation of patients with traumatic brain injuries, and especially the importance of symptom analysis in single-case studies.

For 11 years, *Acta Neuropsychologica* has published clinical articles (original research and case studies), as well as reviews, essays, and articles in neuropsychology, psychiatry, neurology, neurosurgery, and rehabilitation. Since the very beginning, Prof. Pąchalska has been Editor-in-Chief, and Prof. MacQueen has been Language Editor. There are three outside editors, distinguished specialists in the neurosciences and honorary members of the Polish Neuropsychological Society, who are responsible for representing the periodical in different parts of the world: In North America, Prof. Jason W. Brown; in the Asia-Pacific region, Prof. John R. Hodges; and in Russia, Prof. Yurii D. Kropotov. *Acta Neuropsychologica* has four Associate Editors: Prof. Michał Harciarek, Prof. Anna Herzyk, Prof. Bożydar L. J. Kaczmarek, and Prof. Danuta Kądzielawa. The Book Review Editor is Prof. Mariola Bidzan, and the Statistical Editor is Agnieszka Tomaszewska. The Editorial Board includes representatives from many countries and psychological specialties, not only psychology, neuropsychology and neurolinguistics, but also medicine. Their role is to guarantee that the articles published here display a high scientific level.

This issue of Acta Neuropsychologica begins with a major review entitled: **The history of developmental neuropsychology** written by Prof. Janna Glozman from the Lomonosov Moscow State University. Her paper deals with the theory of the social genesis of higher mental functions (HMF) developed by Vygotsky and Luria. Their systemic cultural-historical approach, the first premise of developmental neuropsychology, stresses the influence of social and cultural factors on the child's cognitive development, the social nature of function formation, and the role of mediation (the use of social

means) in the genesis of HMF. The dynamic ontogenic localization of HMF at various levels is discussed, along with the types of brain structures and their functional integration. The psychogenetic studies done in Russia in the 1920s and 1930s by Luria et al., using the twins method, analyzed genotype - environment relations through cultural-historical theory. These studies revealed changes in the relative impact of heredity and environment due to modifications in mental functioning in response to different educative procedures and the role of speech acquisition in mental development. These psychogenetic studies proved that speech and language have a formative effect on mental processes, and that twins form a risk group in terms of mental development. The psychogenetic studies by Luria also formed the basis of neuropsychological remediation, especially the principles of developing games for small children. The differences between the Russian and Western approaches in developmental neuropsychology are discussed, as well as trends in the progress of developmental neuropsychology. This progress is due to the tendency to analyze the dynamics of brain / mind functioning and interaction through the social conditions of a person's life.

The first research article, written by Aleksandra Błachnio from the Institute of Psychology, Kazimierz Wielki University in Bydgoszcz, and Leszek Buliński from Ateneum University in Gdańsk is entitled: **Securing health: social rehabilitation and well being in late adulthood.** The authors state that a natural and common experience, aging can be a source of personal-growth, provided the aging person knows how to face its challenges and to deal with its limitations. Re-education and social rehabilitation can significantly improve senior citizens' situation. Health and social support are important factors in seniors' quality of life, and can be preserved into a relatively advanced old age. This research involved 181 volunteers, 95 women and 86 men, from 65 to 91 years of age. All participants were interviewed on their physical health. They also completed the Satisfaction with Life Scale and the Health Behavior Inventory. The interviews proved that many participants suffered from age-associated diseases, but there were also a few who reported no chronic diseases. The life satisfaction of the subjects turned out to be moderately positive, with no significant difference between men and women. Analysis of health behaviors showed that they were rather health-focused. It was also observed that the female and male respondents' scores differed significantly in two subscales: proper nutrition habits and preventive behaviors. This study can provide useful information for health care practitioners and researchers, epidemiologists and social care workers to better understand the real needs of senior patients. These seniors were aware and self-reliant in their health behaviors, and showed positive life satisfaction. This positive correction of the picture of aging, together with further education and counseling, can improve senior citizens' socioeconomic status.

The third research article by Valentina I. Bykova, Ekaterina V. Fufaeva, and Ekaterina A. Lvova from Clinical and Research Institute of Emergency

Pediatric Surgery and Trauma in Moscow, is entitled: **The specific nature of psychological rehabilitation for children after severe traumatic brain injury at the early stages of recovering consciousness.** Psychological support for children with TBI and their families plays a very significant role in early neurorehabilitation. The aim of this study was to investigate some particularities of psychological support for children afflicted with severe traumatic brain injury.

30 children aged 11-16 with severe traumatic brain injury (GCS≤ 8) participated in the study. A case study technique was employed. The parents' involvement in the rehabilitation process was studied, using clinical interviews and observations. Two complementary directions were identified as regards children's psychological rehabilitation after severe TBI: the psychological support offered by the parents and psychological work with children who are in states of consciousness that have been profoundly altered. In children the interaction with parents becomes important, because trauma causes dysfunction in the family. Analyses of clinical cases using case histories where one can find information about signals coming from children in such states of consciousness during psychological contact have revealed common patterns in the dynamics of recuperation. As the energetic and functional possibilities of patients improve during their vegetative state, a number of physical manifestations start to appear. Afterwards, mimetic and emotional reactions emerge, and consequently the amount of body "gesturing" increases. Thus psychological help for children with altered states of consciousness is an important procedure in early neurorehabilitation, insofar as their contact and interaction with the outer world is concerned.

The fourth research article, written by Piotr Francuz from Department of Experimental Psychology, Catholic University of Lublin, Aneta R. Borkowska from Department of Clinical Psychology and Neuropsychology, Maria Curie-Sklodowska University in Lublin, Paweł Soluch from NeuroDevice Group in Warsaw, and Tomasz Wolak from Institute of Physiology and Pathology of Hearing in Kajetany is entitled: **Analysis of brain activation in teenagers with isolated dysorthography (spelling disorder) and good spellers during a spelling assessment task.** There has been little research on the neural correlates of writing in children and teenagers. The purpose of the present study was to describe brain activation in a group of teenagers with isolated dysorthography vs. teenagers with good spelling skills, during a task involving the assessment of spelling accuracy in words containing an orthographic difficulty. The results will allow for conclusions relating to neural mechanisms underlying the isolated developmental disorder connected with learning to spell correctly. The participants included 15 subjects with isolated dysorthography and 14 good spellers, aged 13-15. An fMRI examination was performed to obtain data on brain activation prompted by visually presented words (correctly and incorrectly spelled). The participants were asked to judge if the words were spelled correctly or not. The group with dysorthogra-

phy was found to activate a total of 18 clusters, while the controls activated 7 clusters. An analysis of the tables shows that the structures activated in the two groups do not overlap. In the group with dysorthography, posterior and anterior cortical areas were activated, while in the control group activation was found mainly in the cerebellum. Both groups showed activation in the middle occipital gyrus; however, in the controls this was in the left hemisphere, while in the subjects with dysorthography it was in the right hemisphere. The cerebellum was active only in the controls. It allows the conclusion that cerebellar deficit may be one of the significant mechanisms leading to learning difficulties manifesting as isolated spelling disorder.

The fifth research article, written by the authors from Lomonosov Moscow State University: Nikita A. Khokhlov, Maria S. Kovyazina is entitled: **Methodical and methodological problems in the study of functional brain asymmetry in the modern neuropsychology.** Diagnosis of interhemispheric asymmetry is an actual problem of modern neuropsychology. The researches show that tests for the diagnosis of one type of functional asymmetry often produce inconsistent results. The author conducted a study to see how the results of different tests for the diagnosis of interhemispheric asymmetry are interconnected. The additional objective was developing a method that enables the calculation of tests weight. The study involved 116 subjects aged 16 to 23, including 37 men and 79 women. The subjects performed the following tests and analyses: A.P. Chuprikov questionnaire, „Napoleon pose", „Applause", „Crossing of fingers", „Aiming" and „Rozenbakh test", and dichotic listening to assess audioverbal asymmetry (20 subjects did not do it). Significant correlations were obtained only between self-reports, Chuprikov questionnaires and „Crossing of fingers" test, and between the results of Rozenbakh test and dichotic listening. The „Crossing of fingers" test correlates with other manual tests negatively. This indicates that at crossing the fingers on the top there is a finger of non leading hand. It implies that the assumption of the independence of manual, audioverbal and visual fields is likely to be diminished. The new method of evaluation of the integral index of asymmetry can be used to divide subjects into groups according to the degree of functional brain lateralization. The evolutionary approach using achievements of comparative physiology can be used as a methodological basis of human interhemispheric asymmetry studies.

The sixth research article, written by M.S. Kovyazina, D.A. Kuznetsova from Department of Psychology, Lomonosov Moscow State University in Moscow is entitled: **Priming effects in individuals with corpus callosum pathology.** One of the methods that allows us to investigate the lateral organization of involuntary memory is priming. Originally this method was developed as a way to examine visual perception and visuomotor coordination in a cognitive paradigm. Eventually, it became clear that the capabilities of priming are much broader. Among other things it provides a unique possibility to examine involuntary memory in subjects with corpus callosum pathology (CCP), since

it allows stimuli to be presented in different visual hemifields. The aim of this study was to identify and analyze the contribution of interhemispheric interaction in the work of involuntary memory. In this study the authors examined 52 normal subjects and 16 subjects with CCP, using the method of priming. It was stated that in normal subjects there was a significant correlation between reaction time (RT) and priming. In the case of a relevant prime, RT decreased; in the case of an irrelevant prime, RT increased. The authors also discovered that in conditions with no priming, the right hemisphere reacts faster than the left. In subjects with CCP it observed priming system impairment: RT increased when the experimental conditions required interhemispheric interaction. The experiment demonstrated that the corpus callosum has a major influence on the process of selectivity in involuntary memory and learning, and in normal subjects distributes the energy between the brain hemispheres, suppressing the subdominant hemisphere in the present activity, thus forcing interhemispherical asymmetry.

The seventh research article, written by Dariusz Wieczorek from Department of Rehabilitation, Medical University in Gdansk, Bogna Brockhuis from Department of Nuclear Medicine and Radiological Informatics, Medical University in Gdansk,Emilia J. Sitek from Department of Neurological and Psychiatric Nursing, Medical University in Gdansk, Piotr Lass from Department of Nuclear Medicine and Radiological Informatics, Medical University in Gdansk, Weronika Wańska from Department of Neurology, St. Adalbert Specialized Hospital in Gdansk, and Jarosław Sławek from Department of Neurological and Psychiatric Nursing, Medical University in Gdansk is entitled: **Memory impairment in Dementia with Lewy Bodies relative to Alzheimer's disease and Parkinson's disease with dementia.** The cognitive profiles of patients with dementia with Lewy bodies (DLB) and Parkinson's disease with dementia (PD-D) are quite similar, though different from Alzheimer's disease. However, studies comparing the memory performance of patients with DLB, PD-D and AD are rare. Patients with DLB, AD and PD-D – matched for general cognitive status – were compared on a range of memory measures. Semantic memory, verbal fluency and verbal learning were assessed. Delayed verbal recall was better preserved in DLB and PD-D than AD. Semantic memory was better preserved in PD-D than AD. Neither letter nor category fluency differentiated between the groups. This study shows the usefulness of the Auditory Verbal Learning Test (AVLT) as an easily administered verbal learning measure for further research assessing episodic memory in DLB in comparison to PD-D and AD.

The first review article written by the interdisciplinary team: Marina A. Emelyanova from The National Research University Higher School of Economics in Moscow, Anatoliy A. Skvortsov from The Centre for Speech Pathology and Neurorehabilitation in Moscow, Anna V. Vlasova (Zaykova) from The Russian National Research Medical University in Moscow, and Konstantin V. Koryagin from Moscow Research Institute of Psychiatry in Moscow is entitled: Apraxia

research: Russian and modern neurocognitive traditions. Three scientific traditions of apraxia research are presented in this article: Luria's theory of the systemic structure and dynamic localization of higher mental functions, Bernstein's level theory of motor acts, and the neurocognitive approach. The apraxia classification developed by Luria, the classification of movements widely discussed in neurocognitive tradition, and Bernstein's level structure of the motor act are presented schematically. The strengths and limitations of each of these scientific schools are discussed. The principles of apraxia assessment in Luria's and the neurocognitive framework are analyzed. It is concluded that Luria's approach and the neurocognitive tradition of apraxia investigation are quite similar. Bernstein's ideas were formed more than fifty years ago, but seem insightful and fruitful today. According to Bernstein, voluntary movements have some essential features that are not currently taken under consideration. From his point of view, movements are meaningful (determined by a motor task), holistic, hierarchic, dynamic and creative. These postulates were discussed in many of his now-classic works. Unfortunately, they are not widely known among clinicians, yet Bernstein's concepts can significantly enrich our knowledge in the neuropsychology of praxis.

The case study, has been written by the authors from the Department of Personality, Assessment and Psychological Treatment, University in Barcelona: Liudmila Liutsko and Jose Maria Tousis entitled: **Quantitative and qualitative proprioceptive analysis of individual differences: a case study of multiple sclerosis.** Proprioceptive Diagnostics for individual neuropsychological differences, as a basis for temperament and character, was developed within the Mira y Lopez tradition of myokinetic psychodiagnosis, and both theoretical and experimental works in the Mira y Lopez Laboratory of the University of Barcelona using new technologies. Some quantitative parameters observed in proprioceptive fine motor behavior as well as qualitative can be used during test performance. The qualitative aspects of the graphomotor performance of a participant with multiple sclerosis (MS) was distinct from that of hundreds of other individuals with no such diagnosis. Proprioceptive Diagnosis of Temperament and Character (DP-TC) was used to observe fine motor behavior in proprioceptive test conditions. The size and spatial deviations of a participant's performance were distinguished from models, with and without vision, whereas a qualitative analysis (global graphical behavior) provided important complementary information. In the lineograms of left hand anterior movement (right hemisphere) in the proprioceptive sensory condition, the linearity of lines was disrupted: the subjects drew non-linear forms, curves, sometimes figure-eighth, and in parallels, they drew intersected lines instead. If qualitative parameters are important in order to obtain the general individual neuropsychological profile, qualitative information regarding fine motor behavior in proprioceptive sensory conditions could provide a specific pattern of importance in preliminary neurological examinations, and at lower cost. This examination could also help medical

workers to discover the hidden patterns of any neurological pathology, and psychologists to identify any specific individual organization in proprioceptive spatial perception.

I would like to thank Prof. Maria Pachalska, Editor-in-Chief of *Acta Neuropsychologica* for entrusting the editing the issue of the journal to the Ateneum University in Gdańsk. I hope all readers will find something of interest in this issue, for reflection, inspiration and further exploration and research.

Leszek Buliński

Guest Editor

[1] Pachalska M., Kaczmarek B.L.J. (2012) Alexander Romanovich Łuria (1902 – 1977) and the microgenetic approach to the diagnosis and rehabilitation of TBI patients. Acta Neuropsychol 10(3) 2012: 399-417

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THE HISTORY OF DEVELOPMENTAL NEUROPSYCHOLOGY

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SUMMARY

This paper deals with the theory of the social genesis of higher mental functions (HMF) developed by Vygotsky and Luria. Their systemic cultural-historical approach, the first premise of developmental neuropsychology, stresses the influence of social and cultural factors on the child's cognitive development, the social nature of function formation, and the role of mediation (the use of social means) in the genesis of HMF. The dynamic ontogenic localization of HMF at various levels is discussed, along with the types of brain structures and their functional integration. The psychogenetic studies done in Russia in the 1920s and 1930s by Luria et al., using the twins method, analyzed genotype - environment relations through cultural-historical theory. These studies revealed changes in the relative impact of heredity and environment due to modifications in mental functioning in response to different educative procedures and the role of speech acquisition in mental development. These psychogenetic studies proved that speech and language have a formative effect on mental processes, and that twins form a risk group in terms of mental development. The psychogenetic studies by Luria also formed the basis of neuropsychological remediation, especially the principles of developing games for small children. The differences between the Russian and Western approaches in developmental neuropsychology are discussed, as well as trends in the progress of developmental neuropsychology. This progress is due to the tendency to analyze the dynamics of brain / mind functioning and interaction through the social conditions of a person's life

Key words: social genesis of higher mental functions, functional brain organization, differential neuropsychology, neuropsychological tests

INTRODUCTION

The theoretical basis of developmental neuropsychology as well as of general neuropsychology comprises three principles, proposed by L.S. Vygotsky and A.R. Luria:

- the principle of the social genesis of higher mental functions (HMF);
- the principle of the systemic organization of HMF;
- the principle of the dynamic organization and localization of HMF.

These principles derive from the cultural-historical approach to the analysis of the development of HMF and of abnormalities in HMF, that is, orientation not so much to the disease or the defect as to development, looking at the history of culture for the reasons behind mental phenomena and for the means of their remediation. L.S. Vygotsky proved that a defect interferes with the child's appropriation of the culture, but cultural means help the child to overcome the defect. Hence the cultural-historical approach became and remains a methodological basis for remedial education.

The creation by Vygotsky and Luria of the systemic cultural-historical approach in the 1920s and 1930s should be considered the first step towards the emergence of developmental neuropsychology. One of the first studies based upon this approach was a comparative exploration of mental functions in urban, rural and homeless children. The study demonstrated the influence of social and cultural factors on the child's cognitive development (Luria, 1928, 1930).

In all his works, Vygotsky stressed the social nature of function formation and the role of mediation (the use of psychological tools, i.e. social means) in the genesis of HMF (Vygotsky's principle of "doubling experience").

To understand the theory of the systemic structure of HMF in humans the following factors are the most important:

- the variability of interfunctional relations and connections;
- the formation of complex dynamic systems, integrating many elementary functions;
- the generalized reflection of the environment by conscience;
- mediated mental functioning.

Luria's principle of the dynamic ontogenic localization of HMF refers to various levels and types of brain structures and their functional integration, while acknowledging the same cognitive activity by children of different ages.

Any analysis of Russian developmental neuropsychology cannot omit the psychogenetic studies performed in the 1920s at the Eugenics Office of the Academy of Sciences in St Petersburg, created in 1921, and in the Laboratory of Heredity and Human Constitution at the Moscow Medico-Biological Institute, created in 1928. The former used the genealogical method, while the latter used the twins method, which later proved to be more informative (Ravich-Sherbo & Sygal, 2003), and compared the impact of genetic and environmental factors on the individual variability of the psychological and neurophysiological features of children.

Luria started his work at the Medico-Biological Institute in 1932, the same year in which a paper was published by M.S. Lebedinsky, entitled "The problem of heredity in psychology and the twins method." This paper analyzed the method and the results of the assessment of different mental features (reasoning, mediation capability, temperament) in twins at different ages. It revealed greater genetic similarity of most features in monozygotic twins, as compared to dizygotic, and also the dependence of similarity on the age of the twins and the function assessed. From 1932 till 1937 (when the Medico-Biological Institute was closed and the study of genetics was prohibited), Luria directed studies of genotype-environment relations through cultural-historical theory (Fig. 1). The group included M.S. Lebedinsky, A.N. Mironova, N.G. Morozova and F.Y. Yudovich. They were the first in Russia to use the "twins model" in experimental studies of the genetic mechanisms of mentality. The difference from similar studies in Western countries consisted in the use of special tests addressed predominantly to "natural" (genetic) or cultural (environmental) factors, instead of using standardized batteries measuring IQ. For instance, in nonverbal tasks, which better reveal "natural" factors, the results were more similar in monozygotic twins than in dizygotic ones.

The program for the study of genotype/environment relations, based on the Vygotsky-Luria theory of mental development, revealed changes in the relative contribution of heredity and environment, due to modifications in mental functioning in response to different educative procedures, and to the role of speech acquisition in mental development (Lebedinsky, 1932; Mironova & Kolbanovsky, 1934; Luria, 1936, 1948, 1963, 2002; Ravich-Sherbo & Sygal, 2003). A study of 130 pairs of twins ranging from 6 to 11 years old revealed, for instance, that elementary memory is determined by genotype in all age groups, while mediated

Fig. 1. Some of the twins that participated in the research work of the psychological laboratory of the Medico-Biological Institute (from Luria's archive)

remembering using pictograms was dependent on genotype only in preschoolers. To generalize, the influence of "natural" factors on child cognitive functions decreases with age, while the influence of "cultural" factors increases. "This evidence indicates that during ontogenic development there is dramatic change not only in the psychological structure of mental processes, but also in their internal nature" (Luria, Symernitskaya & Tybulevich, 1973, p. 112).

The research work in the Medico-Biological Institute permitted Luria to state the main ideas of developmental neuropsychology: "mental development in childhood is first of all a modification in the child's forms of activity, complication of the structure of this activity and enrichment of the mental processes developing inside this activity" (Luria, 1948, p. 34). In the process of development a mental function "does not stay the same; … it changes significantly its own structure, it solves the same task using different operations" (Luria, 2002, p. 17). Moreover, „the genotype influences to a great degree the speed of appropriation of these 'cultural' forms of mental activity…" (Ibid., p. 18).

The psychogenetic studies first pointed to the formative effect of speech and language on mental processes, and then revealed that twins form a "risk group" in terms of mental development. For instance, Luria and Yudovich assessed a pair of 5 years old twins with a lower than normal level of speech and general mental development. The authors supposed that the cause was that the "twin situation" did not stimulate verbal activity, replacing it with more primitive forms of communication. The researchers then placed each twin in a different group of the kindergarten, so that an objective need was created to acquire speech as a means of communication (Luria & Yudovich, 1959). Also, special lessons to develop speech were given to one of the pair. In 3 months, the verbal abilities of these two children (both vocabulary and grammar) changed significantly, and their general mental development improved, to a greater degree in the child who had speech therapy. Therefore, when an objective need for verbal communication was created, not only did both children acquire new verbal means for communication, but significant modifications were provoked in the structure of their conscious activity, based on speech and language.

The psychogenetic studies by Luria also formed the basis of neuropsychological remediation, namely the principles for developing games with small children. In a pair of monozygotic (genetically similar) 6-year-old twins, one was tasked with a construction activity with cubes using a "step by step method" (i.e. copying of teacher's actions), while the second twin was given the "model" method, where he saw only the general shape of the construction and had to select the elements fitting this shape himself. The second version of the game, aimed at developing visual reasoning and constructive analysis and synthesis abilities, was much more efficient, and the resulting development included some other forms of creative activity and was stable, being evident 18 months after the end of the program (Luria, 1948).

In Western countries, developmental (also called pediatric) neuropsychology became a major area of research and practice during the second half of the 20th

century. "It was in the 1960s that the clinical picture of the 'clumsy child' (renamed *developmental dysgnosia* and *dyspraxia*) was described, specific reading disability (renamed *developmental dyslexia*) was investigated from a neuropsychological standpoint, and the concept of *minimal brain dysfunction* (MBD) was formulated to account for these and a myriad of other behavioral disabilities in children. Since that time pediatric neuropsychology has become a flourishing area of inquiry and practice, generating new knowledge and deeper understanding, with the result that today the evaluation and management of children with documented or suspected brain dysfunction by well-informed neuropsychologists are incomparably more insightful and effective than was the case 20 years ago" (Benton, 2000, p. XV).

To conclude, I would like to emphasize that the origin of developmental neuropsychology, as well as the whole development of Russian psychology beginning with Luria's school, is due primarily to the main achievement in the history of psychology: the creation of cultural-historical psychology, which has greatly influenced clinical neuropsychology all over the world.

TRENDS IN THE PROGRESS OF DEVELOPMENTAL NEUROPSYCHOLOGY

The progress of developmental neuropsychology follows a general tendency all over the world to replace "static neuropsychology" (relating the subject's behavior, whether adult or child, to defined brain areas) with "dynamic neuropsychology" (analyzing the dynamics of brain/mind functioning and interaction through the social conditions of the person's life, that is, viewing childhood disorders within a developmental context (Rourke, 1982, 2000; Tupper, Cicerone, 1991; Glozman, 2002, 2010). Such an approach runs contrary to the"biologizing" tendencies of the psychology of the 19th and 20th centuries, and is of value, given that "a division of 'natural sciences' and 'mental sciences' into different scientific paradigms risks bisecting psychology into two different ones, lacking a common subject and methods of research" (Akhutina, 2004, p. 20). This is very close to the definition of „real psychology" by Luria. In his first book, written in 1922, Luria set himself the task of "studying the human person as a biological, social and psychological unity" (Luria, 2003, p. 296). Analogously, Lev Vygotsky (1925) represented the psychology of the future as the study of "a biosocial synthesis" – a union of natural and human sciences.

It is not surprising that the main causes of delayed development (immaturity) of a child's functional mental systems is, according to Korsakova et al. (2001), an unfavorable environment during this child's formative years (complicated intrafamily relations, bad conditions of everyday living, harmful ecological factors, lack of socialization or participation in educative and upbringing programmes).

This explains the predominant importance of *functional diagnostics* (as distinct from the *topical diagnostics* of immature or impaired brain structures) of defects preventing the child from acquiring knowledge and abilities, adapting to society

(school or family), and developing to a greater degree his own potential and personality.

The current period of progress in neuropsychology (both of adults and of children) is characterized by extensive development all over the world. The neuropsychologist is assessing now not only patients with organic focal brain lesions, but also patients with endogenous, genetic and functional disturbances, with individual variations of normal mental functioning, consequences of specific social situations of development (such as social deprivation or bilingualism) and others. This increased range in the types of persons referred for neuropsychological assessment is explained first by the fact that specialists in different branches of psychology have realized the possibilities of Lurian neuropsychological assessment for the differential and functional diagnostics of a great number of abnormal or atypical developmental conditions. Secondly, modern methods of neuroimaging reveal organic cerebral pathology in patients with endogenous and functional disorders, such as stuttering, schizophrenia, or autism. Thirdly, the sphere of neurocognitive disorders increases in conjunction with our understanding of systemic disturbances, including specific primary, secondary and tertiary symptoms (due to functional reorganization during adaptation to disease or resulting from a particular social situation of development. The fourth reason is the common understanding of the role of dysontogenesis for neurocognitive disorders, resulting in greater significance for the neuropsychological assessment of different kinds of abnormal or atypical development.

Another feature of contemporary progress in developmental neuropsychology (as well as other branches of neuropsychology) is a tendency to “enlarge the sphere of application of neuropsychology outside the clinical, pathological cases of disturbances in human mental activity to the study of the mentality of healthy subjects. First of all, it regards cases of deviations (for different reasons) in mental and cerebral functioning interfering with the person’s adjustment in various living situations” (Korsakova et al., 2001, p. 7).

The task in the progress of developmental neuropsychology consists in the need to pass from a phenomenological description of abnormal child development to the study of the interactions between brain, genetics, sociology and personality in the formation of different kinds of abnormal or atypical development. In other words, developmental neuropsychology should now be based on an integrative multidisciplinary approach, founded by E. Lenneberg (1967).

Due to these tendencies in the progress of developmental neuropsychology, it becomes a base for the creation of a service of applied psychology for education (Asmolov, 1998).

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B – Data Collection
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SECURING HEALTH: SOCIAL REHABILITATION AND WELLBEING IN LATE ADULTHOOD

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SUMMARY

Background: As a natural and common experience, aging can be a source of personal-growth, provided the aging person knows how to face its challenges and deal with its limitations. Re-education and social rehabilitation can significantly improve senior citizens' situation. Health and social support are important factors in seniors' quality of life, and can be preserved into a relatively advanced old age.

Material/ Methods: Our research involved 181 volunteers, 95 women and 86 men, from 65 to 91 years of age. All participants were interviewed on their physical health. They also completed the Satisfaction with Life Scale and the Health Behavior Inventory.

Results: The interview proved that many participants suffered from age-associated diseases, but there were also a few who reported no chronic diseases. The life satisfaction of our subjects turned out to be moderately positive, with no significant difference between men and women. Analysis of health behaviours showed that they were rather health-focused. We also observed that our female and male respondents' scores differed significantly in two subscales: proper nutrition habits and preventive behaviors.

Conclusions: Our study can provide useful information for health care practitioners and researchers, epidemiologists and social care workers to better understand the real needs of senior patients. These seniors were aware and self-reliant in their health behaviors, and showed positive life satisfaction. This positive correction of the picture of aging, together with further education and counseling, can improve senior citizens' socioeconomic status.

Key words: active aging, health behavior, health related quality of life

INTRODUCTION

Aging is a natural stage in every human life, but society perceives it more as a social health problem. Many people try to postpone the onset of old age, because they associate aging with the loss of personal autonomy, health, and physical and social functionality. This assumption is very strong and persistent. But there has also been some improvement: recent advances in gero-science, both theory and practice, have demonstrated increasing interest in active and positive aging. This shift – from negative to positive, from decline to personal growth – is possible, but cannot be taken for granted. In fact, gerontologists (both scientists and practitioners) have been looking for strategies to age well.

The domain of health, well-recognized and described in gero-science, is a significant determinant of positive aging. The available results prove that there is a positive relationship between well-preserved health and quality of life. A relative freedom from suffering, disorders and malfunctions is rather a transient and limited state of affairs among senior citizens. With age, health declines, and the need for assistance, support and help grows urgent. Thus the demand for specialists with a thorough understanding of the aging process – its dynamism and changeability – is growing systematically.

To date scientists have lacked an instrument to differentiate the normal aging from pathogenic changes. However, the preserved negative stereotype of aging that puts emphasis only on decline and loss displays a false picture of aging. To reveal the facts, we chose as our objective to explore the quality of aging, selecting as its indicators health and satisfaction with life. Although our research plan replicates some previous studies, we conducted it on a population of Polish seniors, which we would indicate as an added value. There is very little data in the English literature regarding the aging process and health of Polish seniors. We also wish to popularize the concept of positive aging and discuss some aspects of its dependence on social rehabilitation. The social environment should be better recognised and used as a resource for seniors that can effectively postpone frustrating dependence and helplessness.

AGING AND HEALTH

Our current state of knowledge on aging indicates that the number of diseases increases with age. These are typically chronic and recurrent. Over 80% of seniors suffer at least one chronic disease, and many are diagnosed with multiple conditions that require regular treatment. Describing the health status of the aged persons, specialists usually list typical age-related diseases, such as:

- cancer;
- cardiological disorders (Kurpesa & Krzemińska-Pakuła, 2008);
- metabolic disorders (obesity; diabetes type 2; Kowalska & Cieślińska-Świder, 2010);
- joint dysfunctions (hip in particular; Salkeld, Cameron & Cumming, 2000);
- visual and auditory impairments;

- Alzheimer's disease;
- depression;
- dementia.

Along with such diseases, aging is also associated with other symptoms, such as memory lapses, a general decline in physical fitness and mobility, and decreased physical attractiveness. Seniors often suffer from sleeping problems. With age the person's performance is impaired, especially by neurodegenerative processes in the brain. This produces not only different forms of aphasia (with naming problems, impaired verbal memory, word repetition; cf. Pąchalska, 1999), but also other communication disorders, such as off-target verbosity or tip-of-the tongue phenomena (Świątek, 2007). Seniors show signs of inability to perform activities of daily living (ADL), visuospatial disorientation, autobiographical memory disturbance, and in some cases also bouts of aggressiveness, executive dysfunction, and identity disturbance.

This dramatic picture of decline, deterioration and senility frightens the average person, which accounts for the sometimes frantic efforts to postpone the onset of old age. Meanwhile the personal experience of "getting old" and "being old" can in fact be positive. This new approach has become popular among specialists, who tend to underline the individual, dynamic, and diverse nature of aging (Błachnio, 2011; Błachnio & Buliński, 2013). This shift to a more positive and active formula of aging is attainable by everyone. The specialists focus more on individual and environmental resources that can help to retain, protect and build seniors' autonomy in everyday functioning and to diminish their stress in situations when the environmental demand exceeds their capacities (Hobfoll, 2006). Ann A. Wilcock (2007) believes that seniors should simply continue to do, to be, to become and to belong in ways meaningful to each of them. If older people manage to accomplish this they gain wellness and improve their quality of life. This new approach is appealing, but in society the negative attitudes to aging prevail.

Tornstam has shown that most people have limited knowledge about aging and often preserve false, mostly negative images. The statements derived from his empirical study point to a still predominantly negative approach to senior citizens (older pensioners) who are perceived as being bored, having no life satisfaction, having poor eating habits, being bed-ridden and hard of hearing (Tornstam, 2007). These findings, along with our own previous research (Błachnio, 2011; Błachnio & Buliński, 2013), indicate the importance of further investigation of the aging process. The more we search, the better we understand and popularize the facts about later life. Although there are many international studies on senior populations, in the English literature we lack data on the quality of old age in Poland. Even the latest project, PolSenior, although it illustrates an interesting relation between satisfaction with health and satisfaction with life, gives only a very general picture of Polish aging (Waszkiewicz et al., 2011). For our own purposes, one of their conclusions is especially worth repeating: they found no statistically significant differences in the subjective evaluation of health condition by region. Thus we can presume that the results of our smaller sample can refer

to the general population of Polish seniors. All these arguments taken together encourage us to measure how Polish seniors experience their aging. We focused on their health and life-satisfaction. The results are not presented to astonish the reader, but rather to recover a lost truth about how the elderly handle the process of growing into advanced old age.

MATERIAL AND METHODS

Participants

The aim of the study was to measure the health indicators and habits of Polish seniors, as well as their wellbeing. in order to measure the quality of the aging process. The sample included 181 volunteers, 95 women and 86 men, ranging in age from 65 to 91 years (M=73, SD=6.54). A more detailed description of the age variables is presented in Table 1. Information about educational level was provided by all respondents: of these, 24% had a primary education, 23% had a vocational education, 37% had a secondary school diploma, and 16% had a college degree. All these seniors lived in a private household, the majority (75%) with a spouse or other family, the rest (25%) alone.

Table 1. Description of the research sample

Gender	Number	Age			
		M	Min.	Max.	SD
Females	95	73.2	65	88	6.64
Males	86	72.9	65	91	6.46

Procedure

The participants were tested individually or in small groups. First, all participants were asked to report on their demographic characteristics (age, gender, level of education, marital status, and living arrangements) and health conditions. The interview focused mostly on their physical health: the checklist consisted of the 10 most prevalent chronic illnesses in later adulthood (e.g., arthritis, diabetes, heart disease, and cancer). The respondents were asked to indicate only those conditions that applied to them. The last category was “other, ” which could be filled with individual diseases. Then the participants completed two short questionnaires:

- the Satisfaction with Life Scale (Diener, Emmons, Larsen & Griffin, 1985; Polish version adapted by Juczyński, 2001);
- the Health Behavior Inventory (Inwentarz Zachowań Zdrowotnych – IZZ, Juczyński, 2001).

The Satisfaction with Life Scale (SWLS) contains five items to measure global cognitive judgments of one's life satisfaction. Respondents judge and evaluate – using a 7-point scale, from 7 ("strongly agree") to 1 ("strongly disagree") – how much they agree or disagree with each of the 5 statements.

The Health Behavior Inventory (IZZ) is a 24-item questionnaire developed and standardized by Juczyński (2001). It measures a person's behaviours that may either diminish or increase the risk of illness. Respondents evaluate their own actions using a 5-point scale that ranges from 1 ("almost never") to 5 ("almost always"). The IZZ questionnaire assesses the general level of health behaviours. It also allows us to measure four separate health-related subscales: proper nutrition habits, preventive behaviors, positive psychological attitude, and health practices.

Statistical analyses were performed using STATISTICA version 9.0.

RESULTS

The results from our interviews indicated that the participants involved in our study experience their aging variously. For example, there were several persons who were in perfectly good health, and declared no chronic diseases (7.7%, n=14). The rest of our respondents suffered from 1 to 7 chronic diseases. Among the chronically ill subjects, the affliction most often mentioned was hypertension. All these ailments and malfunctions were age-associated diseases. A more detailed report on the participants' responses is presented in Fig. 1.

Our study focused on seniors' life satisfaction (Table 2). The data we gathered indicated that their life satisfaction is moderately positive. In comparison to Juczyński's normative sample (N=555, adults aged 20-55), the mean scores achieved by our subjects were rather high. But the 39 older persons interviewed by Juczyński (2001) had an even higher score (M=24.40, SD=6.99). Further analysis showed no significant differences between men and women in terms of life satisfaction.

Further analysis concerned the subjects' health behaviors. Their general health behavior index turned out high (70^{th} percentile; Juczyński 2001), which suggests that they are more health-focused. Their scores were closer to patient subpopulations than to the scores of Juczyński's normative sample of (2001). The gender differences in this case were significant – the women's general indicator of health behaviors (M=88.57) was higher than the men's score (M= 83.76 ; t=2.35, p=0.01).

A comparison of the subscales showed that men are less focused on proper nutrition habits (t=2.86, p=0.00), and less interested in preventive behaviors (t=2.06, p=0.04) in comparison to women. Older women are more prone (or perhaps trained) to follow a diet, avoid unhealthy food, and limit themselves if necessary. They are also more systematic in preventive behaviors, such as regular medical check-up, an active attitude towards disease prevention, and conscious understanding of different disease processes and possible strategies of recovery.

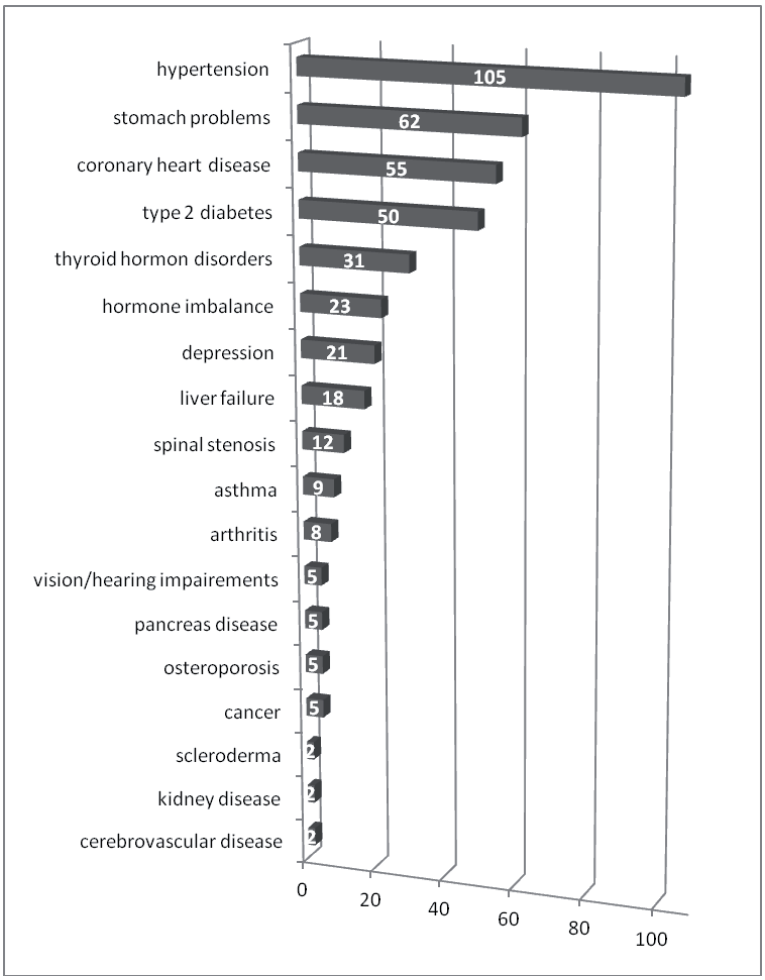

Fig. 1. The results of health conditions interviews (N=181)

Table 2. Results of Satisfaction with Life Scale (SWLS)

	Mean	SD	T test	p
Seniors	22.55	5.67	-	-
Females	22.38	5.93	-0.43	0.67
Males	22.74	5.4		

The scores from other two subscales (positive psychological attitude and health practices) did not differ significantly (t=1.36, p=0.17; t=0.98, p=0.32, respectively; see Figure 2).

Table 3. Results from the Health Behavior Inventory (IZZ)

	Seniors		Females		Males	
	Mean	SD	Mean	SD	Mean	SD
general indicator of health behaviors	86.28	13.93	88.57	12.13	83.76	15.35
proper nutrition habits	20.27	4.79	21.22	4.28	19.22	5.11
preventive behaviors	21.64	4.52	22.29	3.98	20.92	4.97
positive psychological attitude	22.40	4.06	22.79	3.86	21.97	4.25
health practices	21.97	4.16	22.26	3.65	21.65	4.67

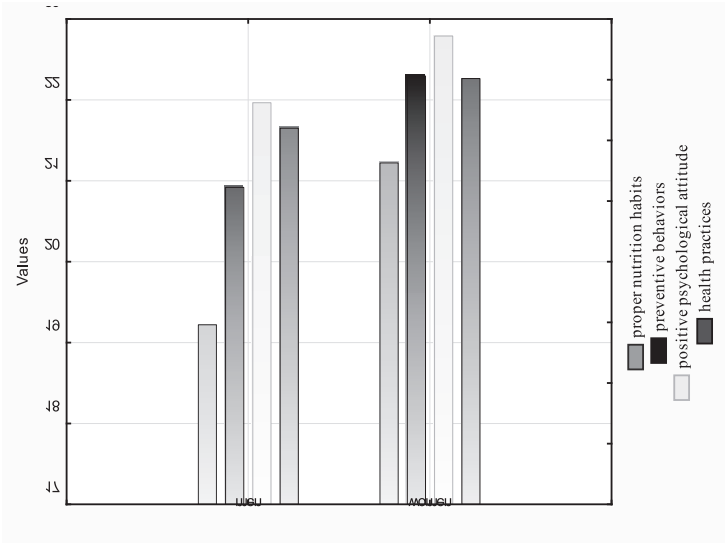

Fig. 2. T values for 4 health-related subscales of the IZZ for men and women

DISCUSSION

We have observed different transformations in the population of senior citizens, including prolonged life expectancy, improved education, and growing awareness of the health being one of major determiners of quality of life in later life. In our study we focused mostly on health. Our objective was to examine the health status of Polish seniors in order to shed some light on their functional (dis)ability. The general tendency turned out to be rather positive; the majority of participants declared satisfactory health, with only one (n=54) to two (n=58) chronic diseases.

Along with the examination of health, we measured the life satisfaction of senior citizens. The authors of the Satisfaction with Life Scale underline that their

tool measures satisfaction with the individual's life as a whole, and does not summarize the degree of satisfaction experienced in particular domains, such as health and finance (Pavot & Diener, 1993). This approach is in accordance with the reflective, more autonomous and integrative picture of aging that constitutes the positive model of aging in Tornstam's gerotranscendence theory (Bruyneel, Marcoen & Soenens, 2005). One of their concepts is a revision of the perception of life and death and a decrease in the fear of death, a redefinition of time, space and objects. Seniors become less self-centered, more independent, and less socially and materially dependent persons. Thus their general approach to satisfaction with life may improve and become positive. Our results confirmed this. Thus we advanced a step further in our educational process to present aging in a better light and encourage people to make active preparation for their old age.

Getting ready for old age includes a life-long learning process that helps senior citizens to acquire and master new skills and habits to remain self-reliant as long as possible. It also develops knowledge of the problems the elderly face, and awareness of how to deal with all the everyday challenges they need to overcome (Halicka & Halicki, 2011). This may help seniors to take responsibility and participate actively in health-oriented behaviors. The results achieved in the Health Behavior Inventory (IZZ) proved that these older persons display an interest and develop habits to preserve their social and individual functionality and self-dependence as long as possible. Thus they manifest a vast range of protective behaviors, such as avoidance of infections, a regular daily rhythm and sufficient sleep time, avoidance of salt and sugar, a diet rich in fruits and vegetables, a personal interest in maintaining close social ties, concern with personal wellness, and avoidance of negative emotions and distress. Although their active attitude is beneficial, it needs to be supported by professional assistance to stabilize healthy behaviors and prolong self-dependent performance in everyday life.

A multidisciplinary team can provide a wide range of well-organized, problem-oriented rehabilitation services. Among seniors these interventions focus mostly on symptom management. The main objective of rehabilitation is to maximize function, and not to cure. Our study showed a positive picture of functionally independent aging, but this state can be prolonged only in a limited range. Both seniors and their family, friends and supporters should develop their knowledge and skills to prepare themselves to deal with all possible aspects of disability in later life. The possible interventions should include:

- optimizing treatment to alleviate the symptoms of diseases and/or disorders;
- increasing support to improve seniors' quality of life.

In general, rehabilitation aims at minimizing the pain and distress of the older patient, and maximizing their personal involvement in recovery. Social rehabilitation involves recruiting others from the patient's family and community to assist the senior in monitoring their health condition, detecting the prodromal symptoms of oncoming dysfunctions, and dealing with new challenges of everyday life.

CONCLUSIONS

The correction of the picture of aging sends a positive message to society, and together with further education and counselling improves the socioeconomic status of senior citizens in the community. Acceptance by the community is – along with health – an important determiner of seniors' quality of life. Thus social rehabilitation may further restore seniors' status through various interventions, such as:

- the development of gerontoscience;
- a media campaign to promote a positive approach to aging;
- popularization of life-long learning, especially the "third age university" (U3A) movement;
- spreading information and training about active aging;
- enhancing seniors' motivation to self-development.

This new approach to aging is grounded in a personal context that is broader than the purely medical, and includes the psychological, social, physical and spiritual spheres. This subject-oriented shift includes terminology replacement: the specialists focus less on the "disability" and "handicaps" of seniors, and talk more about their "activities" and "participation." In our research, we found that our subjects were aware and self-reliant in health behaviors, including proper nutrition habits, preventive actions, a positive psychological attitude and health practices. This corresponds with the relatively positive life satisfaction of senior citizens. Our study, although not exhaustive, describes the current status of Polish aging, which can be used both for clinical purposes and further research applications.

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THE SPECIFIC NATURE OF PSYCHOLOGICAL REHABILITATION FOR CHILDREN AFTER SEVERE TRAUMATIC BRAIN INJURY AT THE EARLY STAGES OF RECOVERING CONSCIOUSNESS

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SUMMARY

Background: Psychological support for children with TBI and their families plays a very significant role in early neurorehabilitation. The aim of our study was to investigate some particularities of psychological support for children afflicted by severe traumatic brain injury.

Material/ Methods: 30 children aged 11-16 with severe traumatic brain injury (GCS≤ 8) participated in the study. A case study technique was employed. The parents' involvement in the rehabilitation process was studied, using clinical interviews and observations.

Results/ Conclusions: Two complementary directions were identified as regards children's psychological rehabilitation after severe TBI: the psychological support offered by the parents and psychological work with children who are in states of consciousness that have been profoundly altered. In children the interaction with parents becomes important, because trauma causes dysfunction in the family. Analyses of clinical cases using case histories where one can find information about signals coming from children in such states of consciousness during psychological contact have revealed common patterns in the dynamics of recuperation. As tje energetic and functional possibilities of patients improve during their vegetative state, a number of physical manifestations start to appear. Afterwards, mimetic and emotional reactions emerge, and consequently the amount of body "gesturing" increases. Thus psychological help for children with altered states of consciousness is an important procedure in early neurorehabilitation, insofar as their contact and interaction with the outer world is concerned.

Key words: coma, neurorehabilitation, parental involvement

INTRODUCTION

With a noticeable increase of pediatric trauma in Russia through the last decade, traumatic brain injury (TBI) remains one of the most significant medical and social problems. In the overall incidence of trauma, severe traumatic brain injury (TBI) varies from 4 to 20% (Konovalov, Likhterman & Potapov, 2002).

In recent years, mortality has declined, thanks to technological development and enhanced approaches to neuroresuscitation and neuroimaging, while the number of disabled children has sharply increased. When it comes to brain trauma, problems concerning TBI outcomes and the quality of life of disabled children and their families has become a critical problem. Thus timely psychological support for children with severe TBI and their families plays a very significant role in early neurorehabilitation.

Within the framework of neurosurgical procedures, brain trauma is an example of impaired anatomical integrity; with respect to neuropsychology, this is an instance of damaged brain activity with diffuse symptoms of cognitive dysfunction. From the point of view of a clinical psychologist, trauma is the destruction of the child's personal wholeness and that of his family. The destroyed wholeness of a family member triggers a chain of deformations and disorders in the entire family system, with alterations in habitual relations, priorities and values. Hence the main task for the rehabilitation team is to restore the integral image of a person in all its complexity.

One of the consequences of severe brain injury may be a long-lasting impairment of consciousness (Zaytsev, 2011; Zaytsev & Tsarenko, 2012; Owen, 2008). Subsequently, a principal sphere of psychological rehabilitation at the acute stage of TBI is the restoration of consciousness. While working with patients during the early stages of consciousness recovery, the clinical psychologist should assume that conscious manifestations are likely to be replaced by unconscious mechanisms and "body gestures" after severe TBI (Mindell & Mindell, 2005).

The term "unconscious" was introduced into scientific parlance by Sigmund Freud in the 19th century (Freud, 1991). Freud spoke of personal, individual unconsciousness. The unconscious can be defined as the sum of those psychic processes that are beyond subjective control. The unconscious includes the following:

1. unconscious motivation;
2. behavioral automatism and stereotypes;
3. supraconscious processes (intuition, inspiration, dreams, insights);
4. subliminal perception, given a large volume of information.

Karl Jung extended the theory of the unconscious by adding a collective aspect to unconscious processes, and highlighting common archetypal features that people possess as bearers of a particular culture (Jung, 2010). It should be noted that Freud and Jung investigated the unconscious in patients who had a clear state of consciousness or suffered from psychiatric disorders that left their verbal functions intact, with which they translated their EGO. Consciousness disorders after severe TBI presumably lead to a mute response from the patient.

In the case of brain trauma, the unconscious cannot be considered "a priori" or clear, because the unconscious part of one's personality is likewise affected by the traumatic deformation caused by the incident. In Jung's works, we find the term "preconsciousness," i.e. something that exists before the foundation for one's conscousness is laid (Jung, 2010).

Following on from Jung, Arnold Mindell, relying on the theory of the unconscious, began to work with patients whose consciousness states were profoundly altered. Mindell developed techniques that allowed scientists to perceive communication signals and have a relationship with such patients at a body level. Mindell has also proposed some new terms: "consciousness continuum" and "primary and secondary signals" (Mindell, 2005; Mindell & Mindell, 2005; Berezkina, 2010). He has also suggested a simultaneous multi-sense translation of signals during contact with other people.

According to the process-oriented approach, the basic principles at work are:

1. Verbal contact with patients is possible only in their immediate field and must develop at a very slow speed;
2. Deep psychological contact is possible using patients' breathing movements;
3. Psychological work may develop only in the state of resonance with the patient;
4. Any movement of the patient, even the smallest, has a psychological implication;
5. During contact with a patient the psychologist is to verbally explain his own movements and the patient's.

The long-term rehabilitation process requires a systematic approach to the setting of tasks, the identification of targets and the methodology used to fulfill them at every stage. The establishment of these tasks and the contribution of each team specialist changes depending on the step of consciousness restoration. For example, the clinical psychologist, being a member of a multidisciplinary team, should try to restore consciousness by utilizing the manifesting signs of the unconscious, while a neuropsychologist should work with patients displaying conscious voluntary movements, and as such try to deepen and widen their range (Bratus, 1993; Bratus, 1988).

It should also be noted that neurorehabilitation after severe TBI must be planned individually for each child, based on his personal peculiarities, possibilities and deficits (Gusarova, Ignatyeva & Maksakova, 2012; Maksakova, Gusarova & Ignatyeva, 2011).

The aim of our study was to uncover some particularities of psychological support for children with severe traumatic brain injury.

The following tasks were outlined:

1. to define the fundamental lines of psychological work during the early stages of recovery after severe TBI;
2. to develop psychological instruments for evaluating consciousness recovery and the communicative possibilities of a child and his environment.

The study was a prospective, longitudinal trial, using case study methodology.

MATERIALS AND METHODS

30 children aged 11-16 with severe traumatic brain injury (GCS≤ 8) participated in the study.

To assess the child's recovery of psychic activity and communication signals, a follow-up chart was used. This instrument assesses 104 communication signals coming from the child and distributes them by categories: verbal and nonverbal. A value from 0 to 3 indicated the degree of intensity for a given signal.

The involvement of parents in their children's recovery process after severe TBI was assessed using interviews and observations.

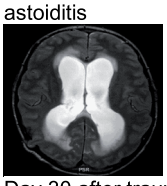
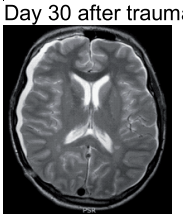
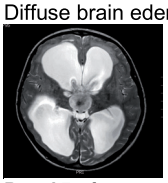
RESULTS

Two complementary directions were defined as regards the psychological rehabilitation of children after severe TBI: psychological support from the parents and psychological work with children who are in consciousness states that have been profoundly altered. In contrast to psychological rehabilitation in adults after brain trauma, in childhood work with the parents acquires an essential role. This is because children and their parents are in a single field of interaction, which is why a child's sufferings involuntarily cause deformation in the entire family system (Bykova, Semenova, Fufaeva, Lvova & Valiullina, 2012; Akulenkova, 2012; Davydkin, Novokonov & Chernykh, 2012; Shuttsenberg, 2011).

Case studies have shown that the adequate participation of parents in the rehabilitation process, such as their involvement, their informational awareness, the levels of their expectations and identified tasks, all play an important role in the rehabilitation process (Table 1). The information presented in Table 1 enables us to determine the factors that essentially influence recovery after severe TBI. The proposed technique allows for complete and accurate analyses of both the medical and psychological components of the rehabilitation process at an acute stage in children after severe TBI; it also permits us to understand and evaluate the role of parents and their participation and involvement in the rehabilitation process. The quality and extent of parents' participation, their "embeddedness" within the context of their child's disease (Beslan, 2009; Venger & Morozova, 2011) and cooperation with physicians may either promote the child's recovery or, unfortunately, hinder it.

While analyzing 30 clinical cases, we discovered that only 52% of parents whose children survived severe TBI could adequately integrate into the process of their child's recovery. In these families, the level of expectations is reasonable, rehabilitation goals are correctly planned at every stage, and there is an observable awareness of "here and now." 34% of parents view their participation in the rehabilitation process as a formality, whereby they feel responsible solely for the provision of nurture, while holding others (including doctors) accountable for their child's recovery. 14% of parents entirely ignore their child's needs during his recovery after severe TBI. This comprises families where the injured child was abandoned by his parents or when the parents have died.

Table 1. The factors that essentially influence recovery after severe TBI

Events	Patient A.	Patient B.
State on admission	On admission Coma 2. GCS– 4-5 scores	On admission Coma 2. GCS– 4-5 scores
MRI brain examination on admission to the hospital	Zygomatico-orbital complex fracture. Fracture of all walls in the left sinus. Consequences of right hemisphere contusion looking like a cystic-glioma transformation. Tense hydrocephaly Periventricular edema. Chronic hematoma of the right hemisphere of the cerebellum. Thrombosis of the right transverse sinus. Open posttraumatic hydrocephaly. Sphenoiditis. Bilateral petrositis, astoiditis  Day 30 after trauma  At discharge	Complex, open comminuted fracture of face skeleton bones and skull base. Depressed comminuted fracture of orbital frontal bone, injuries of left orbit walls, and an open fracture of the bottom of anterior skull notch. Subarachnoidal hemorrhage, traumatic subdural hygroma to the right above the right frontal lobe. Cerebellum hemorrhagic contusion with hemorrhage into the cerebellum peduncle and medial cerebellum structures, perifocal edema and compression of the fourth ventricle. Diffuse brain edema  Day 25 after trauma  At discharge
Total period of hospitalization	57 days	174 days
Surgical interventions	1. Trepannage bilaterally, attachment of ICP monitor (day 2 after trauma) 2. By-pass (day 38 after trauma)	Fluid drainage
Complications	Pneumonia	1. Interstitial lung edema, 2. mycotic infection, 3. pneumonia
Sessions with psychologist	13 sessions with the child and psychological support of his parents	Refusal to work with the psychologist
Psychological peculiarities of parents	Increased contentiousness and anxiety of both the mother and the child	Unconflictive parents, unwilling to hear “another” opinion as to the treatment
Joint work of rehabilitation team and parents	Alignment of cooperation between parents and team Parents’ agreement for surgical interventions Complementarity of all members of the rehabilitation team, adequate and conflictless relations in the team	No cooperation between parents and team Refusal of surgical interventions Multiple problematic and conflict situations within the rehabilitation team, polar opinions on the course of recovery
Consciousness state at discharge	Clear consciousness with elements of confusion in fatigue	Vegetative state

Two years of experience in clinical work with families at the early stages of consciousness recovery in children after severe TBI has allowed us to distinguish some problematic zones that require a psychologist's participation.

1. the reassessment of values and possibilities for social contact after an accident;
2. disorders in the parents' inner chronotype: the replacement of the future by past reminiscences; deformation, fantasy images of the future (Beslan, 2009).
3. the inability to accept their child as a different, considerably changed person after the trauma;
4. the inability to accept responsibility for what is going on and an attempt to "pass on" this responsibility to other family members and doctors;
5. the underdevelopment or incorrect setting of tasks and intermediate goals at each stage of the child's consciousness recovery process;
6. the refusal to accept rehabilitation as a process that requires long-lasting efforts, and overinflated expectations at each stage;
7. the formation of stereotypical behavioral patterns in parents at each stage of rehabilitation, which interfere with the further recovery of their child.

The second direction of psychological work is time spent with the child. The psychological rehabilitation of children with severe TBI may start at early stages of consciousness recovery, commencing from deeply altered states of consciousness (coma, vegetative state, akinetic mutism).

The main aim of psychological work at the acute stage is the assessment of possibilities for the child to interact with the surrounding world, further extension of this contact. and the identification and replacement of inner resources for recovery (Pachalska et al. 2011; 2012a).

To make the psychologist's work more objective and to study the communicative dynamics at the early stages of consciousness restoration, we have developed a Follow-up Chart. This Chart enables us to record 104 communicative signals from a child, as well as their intensity in dynamics and frequency. Communicative signals are conditionally divided into two groups: verbal and non-verbal. Non-verbal signals include body movements, vegetative reactions, gestures and postures, emotional manifestations and mimicry and the possibilities of social symbolic reaction. Verbal signals are recognized through actual verbal responses and timbre coloring, loudness and speech intonation. The Follow-up Chart is filled in every 7-10 days and reflects the dynamics of changes in contact in psychological work with children suffering from a depressed state of consciousness.

Analyses of clinical cases have revealed some common patterns in the dynamics of the number and intensity of communicative signals during consciousness recovery. For example, as the energetic and functional possibilities of patients grow within their vegetative state, a number of body manifestations surface as well. Afterwards, mimetic and emotional reactions emerge, and consequently the amount of body "gestures" increases.

Thus several particularities of consciousness restoration have been found in children after severe TBI:

1. There is considerable regression in children's psychological age, which is displayed through behavioral peculiarities, emotional reactions, together with a decrease in the depth and standard of social interaction.
2. A scenario in which social activity has been restored and contact levels extended has been recorded as well:
   - contact is established with a close adult (mother or father). If no such person is present, such a role may be undertaken by a clinical psychologist;
   - upon increasing energetic resources and functional capabilities, the child begins interacting with other adults. However, contact with other children is not necessarily beneficial to a traumatized child;
   - brief communication with other disabled children or children with limited possibilities. It should be noted that traumatized children show interest in babies;
   - a stage where social contact is established with healthy children. At first, this contact will be limited in time; the child will choose quiet and "slow" children for communication purposes, interacting with whom should prove to be safe.

With less control and arbitrariness, premorbid peculiarities start to occur in the child (character, temperament, psychological evolutional traumas, etc.). All these peculiarities have a more pronounced, accentuated character than before trauma (see also Pachalska et al 2012).

CONCLUSION

1. Two complementary directions have been defined in the psychological rehabilitation of children after severe TBI: psychological support from the parents and psychological work with children whose states of consciousness have been seriously altered.
2. Analyses of clinical cases where the Follow-up Chart was used to record signals from children affected by major changes in their state of consciousness have revealed common patterns in the dynamics of recovery during psychological contact. As the energetic and functional possibilities of the patients grow within their vegetative state, a number of bodily manifestations appear as well. Afterwards, mimetic and emotional reactions emerge, and consequently the amount of body "gestures" increases. Thus, psychological help for children with altered states of consciousness is an important procedure in early neurorehabilitation, insofar as their contact and interaction with the outer world is concerned.
3. It should be taken into consideration that the family of a seriously injured child suffers some deformation as well. The adequate involvement of parents in the recovery process and their cooperation with doctors may either promote their child's recovery or hinder it.

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B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

ANALYSIS OF BRAIN ACTIVATION IN TEENAGERS WITH ISOLATED DYSORTHOGRAPHY (SPELLING DISORDER) AND GOOD SPELLERS DURING A SPELLING ASSESSMENT TASK

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SUMMARY

Background: There has been little research on the neural correlates of writing in children and teenagers. The purpose of the present study was to describe brain activation in a group of teenagers with isolated dysorthography vs. teenagers with good spelling skills, during a task involving the assessment of spelling accuracy in words containing an orthographic difficulty. The results will allow for conclusions relating to neural mechanisms underlying the isolated developmental disorder connected with learning to spell correctly.

Material/ Methods: The participants included 15 subjects with isolated dysorthography and 14 good spellers, aged 13-15. An fMRI examination was performed to obtain data on brain activation prompted by visually presented words (correctly and incorrectly spelled). The participants were asked to judge if the words were spelled correctly or not.

Results: The group with dysorthography was found to activate a total of 18 clusters, while the controls activated 7 clusters. An analysis of the tables shows that the structures activated in the two groups do not overlap. In the group with dysorthography, posterior and anterior cortical areas were activated, while in the control group activation was found mainly in the cerebellum. Both groups showed activation in the middle occipital gyrus; however, in the controls this was in the left hemisphere, while in the subjects with dysorthography it was in the right hemisphere. The cerebellum was active only in the controls.

Conclusions: Cerebellar deficit may be one of the significant mechanisms leading to learning difficulties manifesting as isolated spelling disorder

Key words: fMRI, cerebellum, interior frontal gyrus, parietal lobe, accuracy of spelling, automatization

INTRODUCTION

Despite the fact that difficulties in written language processing include both reading and writing impairments, research on the neurocognitive mechanisms involved has focused mainly on dyslexia (Lipowska & Sajewicz-Radtke, 2012; Krasowicz-Kupis et al., 2009; Pachalska et al., 2009). Studies intended to examine the brain mechanisms related to written language processing include research on reading and writing in normal development, as well as in developmental and acquired pathologies. This includes a search for the critical areas of the brain that are common and specific for various aspects of written language (Richards et al., 2006).

RESEARCH FOCUSING ON HEALTHY SUBJECTS

In terms of its psychological structure, writing is a complex activity, and so activation has been found in various areas of the central nervous system (CNS), depending on which aspect of writing is being analyzed. The most consistent findings involve activation in the left inferior parietal cortex, which is engaged in mapping between phonological and orthographic representations (Booth et al., 2003). Most studies have also demonstrated activation in the left inferior temporal (fusiform) gyrus, which is engaged in orthographic processing (Dehaene et al., 2004), and in the left inferior frontal gyrus, which contributes to the modulation of processes in the posterior regions of the brain (Bitan et al., 2005). Higher accuracy in orthographic decision tasks has been connected with greater activation in the left inferior frontal gyrus (BA 46) and left fusiform gyrus (BA 37), while higher accuracy in auditory spelling tasks correlates with greater activation in the left supramarginal gyrus (BA 40), left angular gyrus (BA 39), and left fusiform gyrus (BA 37; Booth et al., 2003).

Few researchers have focused, however, on finding the neural correlates of writing in children and teenagers (Richards et al., 2005). Three studies have looked for differences between adults and children regarding the assessment of spelling. In one of these, adults demonstrated higher activation than children in the left angular gyrus (BA 39) and left inferior frontal gyrus (BA 9) in a task involving visual spelling, and in the left interior frontal gyrus (BA 44/45/9), left angular gyrus (BA 39) and left superior temporal gyrus (BA 22) in a task involving the auditory assessment of spelling (Booth et al., 2004). Another study reported a modality-independent activation in adults in the left inferior frontal gyrus (BA 9; Booth et al., 2003). When the method of dynamic causal modelling (DCM) was used to examine the effective links between certain areas of the brain, greater top-down control from the left inferior frontal gyrus (BA 45/46/9) to the left inferior parietal lobule/precuneus (BA 40/7; Bitan et al., 2006) was found in adults than in children. Correctness was connected with increased activation in the left inferior frontal gyrus (BA 44/9) and left inferior parietal lobule (BA 40). Given these data, we can assume that the regions of crucial importance in spelling tasks include the left inferior frontal gyrus (BA 44/9), the left inferior parietal cortex (BA

40/39), and the left fusiform gyrus (BA 37), and their importance increases with age and growing ability. Purcell et al. (2011) reported that the perisylvian area, including the inferior frontal gyrus and supramarginal gyrus, appears to play a significant function in phoneme-grapheme mapping in the process of writing.

The left inferior occipitotemporal cortex or the Visual Word Form Area (VWFA), a part of the left ventral visual pathway, is also of importance in the process of writing. It is involved in recognizing a complete word, which is illustrated by more effective processing of familiar vs. unknown words, described as the "orthographic familiarity effect" (Bruno et al., 2008; Kronbichler et al., 2007), and it is engaged in serial, sublexical coding of letter shapes (Schurz et al., 2010; Braet et al., 2012).

Richards et al. (2006) investigated a group of good spellers and readers for activation that would be common and specific for three types of language tasks: phonological, morphological and orthographic. Common areas of activation were found in the left inferior frontal gyrus, the lingual gyrus (bilaterally), the fusiform gyrus (bilaterally), and the left inferior temporal gyrus. Areas with specific activation during an orthographic task included the right middle frontal gyrus, the left superior temporal gyrus, the right middle temporal gyrus and the anterior insula (bilaterally). Only the left cerebellar hemisphere was activated specifically for morphological mapping. In phoneme mapping, the cerebellum was activated bilaterally. Additionally, phonological tasks were found to activate the left orbital frontal gyrus, the thalamus (bilaterally), the right inferior temporal gyrus, and the right cerebellum.

RESEARCH FOCUSING ON CLINICAL GROUPS

Obviously dyslexics do not use entirely different brain systems for language processing, since in various language tasks they show the same activation as in good spellers and readers (Richards et al., 2006). There are also structures which are activated in good spellers and are not activated in dyslexics, and vice versa. Lower activity may indicate difficulties in engaging structures which are necessary for performing a given task. Additional activity may suggest that alternative pathways are being used (compensation; Richards et al., 2006). It appears from this latter study that the right inferior frontal gyrus and right posterior parietal region are particularly significant in orthographic processing (orthographical mapping), and differentiated the group of dyslexics from normal readers; significant change was recorded following treatment. The change was maintained after treatment was completed. Other studies by the same author have reported differences in activation between good and poor readers in the left and right inferior frontal gyrus and bilaterally in the cerebellum (Richards et al., 2008).

Subsequently, Richards et al. (2009) compared children with poor and good spelling skills and reported that good spellers to a greater extent activated the left precentral gyrus, the left post-central gyrus, the inferior frontal gyrus, and the right superior frontal gyrus. In poor spellers, higher activation was found in the

left primary motor cortex, the middle frontal gyrus and cuneus in the right hemisphere, and the middle frontal regions.

The only study to compare brain activation in three groups of children (with dyslexia and writing impairments, with isolated spelling disorder, and good spellers) has been conducted by Gebauer et al. (2012). In comparison with the dyslexic children and controls, the subjects with isolated spelling disorder were found to have stronger right hemispheric activation during an orthographic decision task. The children with isolated spelling disorder activated the inferior and middle frontal gyri bilaterally when processing correctly and incorrectly spelled words, while the other two groups showed bilateral activations only in the case of misspelled words. This suggests that additional right frontal activation may generally be connected with the higher requirements of a task and with mental effort during the performance of the task (Gebauer et al., 2012).

Due to the small number of studies focusing on individuals with isolated spelling impairment (e.g. Richards et al., 2009; Angelelli et al. 2010), there are still insufficient data concerning the brain mechanisms underlying isolated spelling disorder. The purpose of the current study was to describe brain activation in a group of teenagers with isolated dysorthography vs. teenagers with good spelling skills, during a task involving assessment of spelling accuracy in words containing an orthographic difficulty. The results will allow for conclusions relating to the neural mechanisms underlying isolated developmental disorder, which is connected with learning to spell correctly.

MATERIAL AND METHODS

Participants

The study included 15 poor spellers (PS) and 14 good spellers (GS), aged 13 -15. The subjects in both groups attended middle schools in Warsaw and Otwock, Poland. The students' assigment to the clinical group was based on their school documentation containing a diagnosis of dysorthography issued by a psychological and pedagogical counselling center, following a double standardized measurement. Afterwards, the selected children's parents were asked for their consent for the examination and interviewed on their children's development. After the parents' consent was obtained, the children's cognitive development was measured with the Wechsler Intelligence Scale, and their skills related to spelling accuracy were assessed with the use of a dictation test developed by Z. Saduś. This test consists of 26 two-word expressions presenting various orthographic difficulties, mainly words with ó-u, rz-ż, ch-h, pairs of Polish graphemes in which each member of the pair is pronounced exactly the same as the other in standard Polish. The score was based on the number of errors in taking dictation. The ultimate criteria for assignment to the clinical group included:

- isolated spelling disorder diagnosed in a psychological and pedagogical counselling center by a team of specialists (psychologist, pedagogue);

Table 1. Descriptive statistics for both groups

Variable	Poor spellers (PS)		Good spellers (GS)		T	P
	Mean	SD	Mean	SD		
Age in months	166.20	7.93	166.86	7.93	-0.946	n.s.
IQ – full scale	107.67	10.63	111.21	13.35	-0.794	n.s.
IQ – verbal scale	103.43	11.40	110.57	11.27	-1.686	n.s.
IQ – non-verbal scale	111.40	10.34	110.29	14.97	0.235	n.s.
Number of errors in dictation	22	7.11	2.42	1.74	10.010	0.000

n.s. – not significant

- educational history showing no impairment in reading skills;
- an IQ greater than 85;
- poor spelling skills.

The controls did not show impairments in writing or reading. None of the participants in our study had neurological disorders or sensory impairments.

The study groups differed significantly in terms of their ability to correctly write words presenting an orthographic difficulty. No differences were found between the groups in terms of age and intelligence in verbal, non-verbal and full scales (see Table 1).

PROCEDURE

An fMRI examination was performed to obtain data on brain activation. The study was conducted in the MRI Lab at the European Health Center in Otwock.

MR imaging was performed on a 3T MR scanner (Achieva 3T TX, Quasar Dual gradients, Philips, Best) with a BOLD Specialist Package, using an 8-channel Sense Head Coil. A single-shot gradient echo, echo planar sequence, was used for fMRI acquisition (FFE-EPI, TE= 30[ms], TR= 3000[ms], TA= 14:30 [min], slice thickness=3[mm], gap=0[mm], matrix=96x96, FOV= 192x192 [mm], number of slices=42, SENSE factor 1.8, dynamics=290).

The participants' task was to judge the correctness of the spelling of Polish words with orthographic difficulties. The experiment used 18 pairs of words with an orthographic difficulty, six in each category: "ó-u", "rz-ż", "ch-h". We chose words with this type of irregularity in Polish because they are the most difficult for children to learn to spell correctly (Polish orthography is otherwise remarkably regular, especially in comparison to English). Brain activation was prompted by visual stimuli: words were the proper stimulus, while a centered cross served as a neutral stimulus. Each sequence of stimuli was preceded by instructions. During the sequences, the subjects were presented with pairs of words, one above the other. Half of the phrases with orthographic difficulties were pairs with two correctly spelled words, while the other half contained one misspelled word. The

participants were asked to judge if the words were spelled correctly or not. None of the pairs contained the same word used twice. The words were drawn at random from list A (correctly spelled words) and B (misspelled words). The random factor related to the selection of the word, its position on the screen (top-bottom), and the correctness/incorrectness of its spelling. The subjects were exposed to each pair of words for 6 seconds. Following the presentation of each pair of words, the subject responded YES or NO using a response pad adjusted to operation within the magnetic field. The stimuli were displayed via a projector connected to the computer controlling the experiment. The subjects watched the screen via a mirror placed in front of their eyes. Before the examination each individual adjusted his/her position to make sure the image in the mirror was clear and easy to read.

The examination used the following procedure:

- 30-second display of gaze fixation point (cross);
- 30-second display of a set of words (task AB);
- 30-second display of gaze fixation point (Cross).

Subsequent pairs of words were displayed every 6 seconds, which gave 5 pairs of words in each set. The procedure used a total of 36 word pairs with correct spelling and 36 pairs with one misspelled word.

The results obtained during the fMRI study were analyzed using the SPM8 package (Statistical Parametric Mapping).

RESULTS

The AB vs. CROSS contrast was analyzed for these two groups of teenagers with dysorthography and with good spelling skills. AB vs. CROSS contrast means that the activation in the experimental conditions of rest and no activity (CROSS) was subtracted from the activation during the orthographic decision task (AB). Because of the apparent nature of the lack of activity, such a solution was necessary to measure activation for the primary task. The following threshold values of statistical significance were assumed for computing activations:

- p value = 0.001;
- intensity = 3.852;
- cluster size = 25.

The results obtained for the group with dysorthography and for the group of good spellers are presented in tables 2, 3 and 4. Table 2 contains structures in the posterior region of the brain, Table 3 presents anterior structures, and Table 4 shows cerebellar structures. The group with dysorthography was found to activate a total of 18 clusters (see Fig. 1), and the controls activated 7 clusters (see Fig. 2). An analysis of the tables shows that the structures activating in both groups do not overlap. In the group with dysorthography posterior and anterior cortical areas were activated, while in the control group activation was found mainly in the cerebellum. Both groups were found to show activation in the middle occipital gyrus; however, in the group of good spellers this was in the left

Table 2. Analysis of the one-sample t-test for contrast AB vs. CROSS in both study groups, at p=0.001, activations in the posterior region of the brain

Structure	Cluster size	Peak t-value	MNI x,y,z	GS	PS
Middle Occipital Gyrus	5530	9.0574	28 -90 12		R
Middle Occipital Gyrus, Occipital_Inferior_L	109	4.6566	-48 -72 -16	L	
Precuneus , BA 7, Occipital_Superior_L	41	4.6629	-24 -70 34		L
Supramarginal Gyrus, Angular_R	29	6.7579	40 -50 36		R
Precuneus, Occipital_Mid_R	28	5.4788	32 -74 36		R
Inferior Parietal Lobule, Angular_L	149	6.6232	-38 -62 40		L
Inferior Parietal Lobule, Parietal_Inf_L	29	5.1048	-44 -38 44		L
Inferior Parietal Lobule, Parietal_Inf_R	40	4.7747	50 -46 54		R

R- right hemisphere
L – left hemisphere

Table 3. Analysis of the one-sample t-test for the contrast AB vs. CROSS in both study groups, at p=0.001, activations in the anterior regions of the brain

Structure	Cluster size	Peak t-value	MNI x,y,z	GS	PS
Inferior Frontal Gyrus	457	7.0597	-42 24 2		L
Inferior Frontal Gyrus, Insula_R	99	5.085	38 20 -8		R
Inferior Frontal Gyrus ,BA 9, Precentral_L	667	7.7395	-46 4 30		L
Inferior Frontal Gyrus, Precentral_R	34	4.5338	46 2 24		R
Inferior Frontal Gyrus, Precentral_R	102	5.157	52 12 40		R
Middle Frontal Gyrus, Frontal_Mid_Orb_R	49	5.5648	34 54 -10		R
Middle Frontal Gyrus , Frontal_Mid_L	30	4.4507	-44 24 34		L
Superior Frontal Gyrus, Frontal_Mid_R	64	5.3482	38 50 30		R
Frontal_Sup_Medial_L	40	4.4362	2 34 38	R	
Cingulate Gyrus, Cingulum_Mid_R	288	5.8947	10 24 32		R
Parahippocampal Gyrus, BA 27, Hippocampus_L	41	6.4891	-22 -32 -4		L

R- right hemisphere
L – left hemisphere

Table 4. Analysis of the one-sample t-test for the contrast AB vs. CROSS in both study groups, at p=0.001, cerebellar activations

Structure	Cluster size	Peak t-value	MNI x,y,z	GS	PS
Cerebellum Posterior Lobe, Pyramis	26	5.8813	-32 -70 -44	L	
Cerebellum Posterior Lobe, Declive	342	6.237	0 -64 -26	R	
Cerebellum Posterior Lobe, Tuber	27	5.2367	30 -58 -36	R	
Cerebellum Posterior Lobe, Uvula	27	4.1449	-28 -70 -32	L	
Cerebellum Anterior Lobe, Culmen	30	6.8242	-30 -54 -30	L	

R- right hemisphere
L – left hemisphere

hemisphere, while in individuals with dysorthography it was in the right hemisphere. The cerebellum was active only in the controls.

DISCUSSION

It should be assumed that the activation of specific structures in the group of good spellers is adequate for the requirements of an orthographic decision task, and is an indicator of the normal course of these processes. One characteristic trait in the group of good spellers is the activation of the cerebellum. According to the traditional approach, the cerebellum plays a fundamental role in regulating motor processes. Still, current knowledge concerning the tasks of this structure allows for a much broader understanding of its functions. The cerebellum, including in particular the lateral hemispheres of its posterior lobe, has functional links with association cortical areas involved in complex mental processes. These pathways enable the cerebellum to participate in widespread neural circuits controlling sensorimotor, intellectual and emotional processes. Neurobehavioral deficits resulting from cerebellar disturbances may occur even if there are no motor impairments. When a dysfunction is related to the hemispheric regions of the posterior cerebellar lobes, the impairments most frequently reported are connected with executive functions, such as planning, mental flexibility, verbal fluency, abstract thinking, working memory, or functions of spatial cognition and language processing (Schmahmann & Caplan, 2010).

The concept of cerebellar function related to motor learning includes a hypothesis on the analogous acquisition of rules. Importantly, as a result of decreased attention requirements, automaticity allows a primary task to be performed with little or no susceptibility to interferences caused by other tasks. Balsters et al. (2011) suggest that changes in cerebellar activation are linked with the automatic use of cognitive rules, as a result of the interactions between the anterior lobes of the cerebellum and the prefrontal cortex. Cerebellar dysfunctions, then, may

lead to problems with the automaticity of cognitive activities, such as the ability to spell correctly without referring to consciously performed tasks which require effort and executive attention (Balsters & Ramnani, 2011).

The involvement of the anterior cerebellar lobe may suggest that good spellers use automatic motor control. This is consistent with suggestions indicating the existence of such a mechanism. Spelling accuracy is also an effect of motor automaticity developing as a result of multiple repetitions of a specific movement of the hand while writing a given word. Activation in the posterior cerebellar lobe is evidence of automaticity in cognitive processes and language processing in good spellers. Richards (2006) has argued that no or weaker activation of a structure in clinical groups versus controls suggests insufficient involvement of that structure in performing the task, leading to lower effectiveness. In the case investigated by the current study, cerebellar mechanisms which are insufficiently active in the group with dysorthography may contribute to low effectiveness in learning and using the rules of correct spelling. The hypothesis of an automatization deficit connected with cerebellar dysfunction was earlier proposed by Nicolson and Fawcett (Nicolson, Fawcett, & Dean, 2001), who made this assumption taking into account the motor deficits prevailing in dyslexic children and typical for cerebellar impairments, namely discreet impediments to balance, muscle tone and coordination. Although this hypothesis is still subject to discussion, a number of studies suggest that motor deficits result from other developmental problems concurrent with dyslexia, e.g. ADHD (Raberger & Wimmer, 2003).

The subjects with dysorthography activated the middle occipital gyrus, just like the good spellers. However, in the individuals with dysorthography this activation was visible in the right hemisphere, and in the good spellers it occurred in the left hemisphere. In the poor spellers, the activation of the right occipital region may suggest a compensatory mechanism in response to left hemisphere language dysfunctions. No activation in the left hemisphere during the orthographic decision task and activation only in the right hemisphere may suggest that individuals with dysorthography analyze written words in the same manner as drawings, without engaging the language structures of the left hemisphere. The active structures in individuals with dysorthography include the precuneus bilaterally, the right supramarginal gyrus and angular gyrus, and the inferior parietal lobule bilaterally. Their activation suggests that during an orthographic decision task these individuals use the sound-letter relationship and attempt to make a compensatory use of phonology (Booth et al. 2003). Unfortunately, this strategy is not effective for the words used in this study. The selected words with ó-u, rz-ż and ch-h do not differ at the phonological level as a result of the variant spellings. Activation of the right supramarginal gyrus and angular gyrus may serve as an evidence of concentration on the spatial and visual aspects of the letters constituting the written words.

The inferior frontal gyrus in the left hemisphere is frequently indicated as a structure playing an important role in both orthographic and phonological language processing. Activation in this structure has been demonstrated in a num-

ber of different language tasks, mainly those which require some effort and decision-making. Differences in the activation of this structure have also been reported in studies comparing dyslexic children with good readers (Richlan, Kronbichler & Wimmer, 2011). Thus it seems that the differences in the activation of the left inferior frontal gyrus are not specific for writing disorders alone, but for language impairments in general. This is because accurate spelling as an activity does not involve visual perception alone, but also the language system (Polk et al., 2002), and so the latter seems to be one of the impaired processes in spelling disorders. Our results would support this hypothesis. Activation of the left medial frontal gyrus in the group of poor spellers may be attributed to the need for these individuals to intentionally employ working memory by (du Boisgueheneuc et al., 2006). Our study contained a task involving a decision on the accuracy of spelling where the participants were required to engage memory processes; these were found to be less functional in poor spellers and demanded greater effort. Such structures as the cingulate gyrus, parahippocampal gyrus (BA 27), and hippocampus are actively involved in searching memory and making a decision; activation of the cingulate gyrus suggests uncertainty and difficulty in making a decision, as well as the existence of an internal conflict.

CONCLUSION

Our subject teenagers with isolated spelling disorder were found to have different brain activation from that of their peers with normal spelling skills in a task involving a judgement of accuracy in the spelling of words presenting an orthographic difficulty (*rz-ż, ó-u, ch-h*). Activation was found in the frontoparietal structures typical for the initial stages of learning to write. The teenagers with good spelling skills mainly activated the cerebellum, which may be an evidence of automaticity in the process of assessing words in terms of spelling accuracy.

Generally, the observed activation indicates that teenagers with dysorthography attempt to cope with a difficult situation by making more effort, applying strategies based on phonology as an intermediary, and excessively analysing words in terms of visual and spatial traits. On the other hand, in good spellers the orthographic decision process is automatized and does not require such measures.

Taking into account our findings we propose that cerebellar deficit may be one of the significant mechanisms leading to learning difficulties manifested in the form of isolated spelling disorder.

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B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

METHODICAL AND METHODOLOGICAL PROBLEMS IN THE STUDY OF FUNCTIONAL BRAIN ASYMMETRY IN THE MODERN NEUROPSYCHOLOGY

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SUMMARY

Background: Diagnosis of interhemispheric asymmetry is an actual problem of modern neuropsychology. The researches show that tests meant for the diagnosis of one type of functional asymmetry often produce inconsistent results. We conducted a study to see how the results of different tests for the diagnosis of interhemispheric asymmetry are interconnected. The additional objective is developing a method, involving the calculation of tests weight.

Material/ Methods: The study involved 116 subjects aged 16 to 23, including 37 men and 79 women. Test persons performed the following tests and analyses: A.P. Chuprikov questionnaire, ”Napoleon pose”, ”Applause”, ”Crossing of fingers”, ”Aiming” and ”Rozenbakh test”, dichotic listening to assess audioverbal asymmetry (20 subjects did not have it).

Results: Significant correlations were obtained only between self-report, Chuprikov questionnaire and ”Crossing of fingers” test, and between the results of Rozenbakh test and dichotic listening. The ”Crossing of fingers” test correlates with other manual tests negatively. This indicates that at crossing the fingers on the top there is a finger of nonleading hand.

Conclusions: The concept of the independence of manual, audioverbal and visual fields is likely to be changed. The new method of evaluation of the integral index of asymmetry can be used to divide subjects into groups according to the degree of functional brain lateralization. The evolutionary approach using achievements of comparative physiology can be used as a methodological basis of human interhemispheric asymmetry studies.

Key words: interhemispheric asymmetry, functional brain lateralization, differential neuropsychology, neuropsychological tests

INTRODUCTION

Diagnosis of interhemispheric asymmetry is of great importance both for clinical examination, and for neuropsychology of norm. A.R. Luria (1980) noted that the lack of our knowledge in the extent of dominant hemisphere for different individuals and for different functions creates considerable difficulties at clinical study of patients with local brain lesions. The increasing interest in the problem of interhemispheric asymmetry and in the methods of its measuring in modern differential neuropsychology makes urgent rethinking and development of the existing evaluation methods of lateral brain organization.

At the end of XXth century in the Russian neuropsychology it was proposed to evaluate the interhemispheric asymmetry by ”hand-ear-eye” approach. E.D. Khomskaya and I.V. Efimova (1989, 1991) proposed the concept of the profile of lateral organization (PLO), which means the combination of motor and sensory asymmetries. The method of PLO determination is based on the following principles: the use of three types of asymmetries: manual, audioverbal, visual; the assessment of not only the fact of asymmetry, but also its extent; the recognition of varying significance of manual, visual and audioverbal asymmetries. The possible 27 options of the profile of lateral organization of the brain can be combined into five main types: the ”pure” right-handers, right-handers, ambidexters, left-handers and ”pure” left-handers. Studies carried out using this method provided extensive information on the relation of the brain lateral organization with different psychological characteristics (Khomskaya, Efimova, Budyka, Enikolopova, 1997, 2011). The further development of the problem of functional brain asymmetry was in the works of V.A. Moskvin and N.V. Moskvina (2011). They found that lateral symptoms are of heterogeneous nature. Experiments confirmed the existence of the following conditions that affect the laterality: genetic (or inherited), pathological (largely associated with pre-and perinatal brain lesions), forced (due to loss or defect of the peripheral analyzer or leading limb) and functional related to learning activity or particularities of sensorimotor coordination at implementation of certain activities. Of course, these types of lateralization may be differently related to psychological phenomena. Commonly used methods of interhemispheric asymmetry diagnosis not always make it possible to differentiate the types. This makes it difficult to develop the fundamental laws describing the relationship of interhemispheric asymmetry with the psychological characteristics. In addition, Moskvin and Moskvina (2011) are among the first to point out the inconsistency of the results of neuropsychological tests designed to diagnose the same type of asymmetry. For example, after N. Sakano (1982) they pointed out the inconsistency of the ”Napoleon pose” test (”Crossing of hands”) to assess motor manual asymmetry, as it reflects the relative dominance of the frontal areas of the brain. Difficulties in the application of this test are also related to the fact that there is still no single opinion on whether to pay attention to the hand on top, or the elbow lying down on top.

THE AIM OF THE STUDY

The fact that the various neuropsychological tests, conceptually designed to assess one type of asymmetry, do not always give consistent data, making it impossible to sum up the results.

We conducted a study to see how the results of different tests for the diagnosis of interhemispheric asymmetry are interconnected.

MATERIAL AND METHODS

The study involved 116 subjects aged 16 to 23, including 37 men and 79 women. According to self-report, 98 persons were right-handed, 10 – ambidexters, and 8 – left-handed. Test persons performed the following tests and analyses: A.P. Chuprikov questionnaire (Russian analogue of M. Annett questionnaire), manual asymmetry tests – ”Napoleon pose” (on the elbow), ”Applause”, ”Crossing of fingers,” visual asymmetry tests – ”Aiming” and ”Rozenbakh test”, dichotic listening to assess audioverbal asymmetry (20 subjects did not have it).

The correlation between the results of the tests was assessed using Cramer’s V-coefficient, the sign (positive or negative) of the correlation coefficient was determined by the Spearman coefficient. Before evaluating the correlation, Chuprikov questionnaire results and the results of dichotic listening were transferred from raw scores to scale ”right-hander – ambidexter – left-hander” according to the accepted rules. Chuprikov questionnaire: from 24 to 8 points – right-hander, from 8 to -8 points – ambidexter, from -8 to -24 points – left-hander. For dichotic listening: right ear coefficient over 4 – right-hander, from 4 to -4 – ambidexter, less than -4 – left-hander.

RESULTS

The results are shown in the Table 1.

As it can be seen from the Table 1, significant correlations were only obtained between self-report, Chuprikov questionnaire and ”Crossing of fingers” test, and between the results of Rozenbakh test and dichotic listening. Attention is drawn to the fact that ”Crossing of fingers” test correlates with other manual tests negatively. This indicates that at crossing the fingers on the top there is a finger of nonleading hand. There has been no expected connection between the visual tests ”Aiming” and Rozenbakh test, which, in our opinion, it due to accompanied mixing of the variables at the implementation of ”Aiming” test. This test can give incorrect results at the frequently occurred dysfunction of eyelid part of circular eye muscle innervated by the motor part of the facial nerve. In this case, the subject cannot (or can, but with great effort) close one eye without closing the other, due to pathology of the cranial nerves, and not because of the functional brain asymmetry. It is impossible to separate one reason from the other without special neurological examination. The connection between the Rozenbakh visual test and the results of dichotic listening, designed to determine audioverbal asym-

Table 1. Tests correlation matrix

Test	1	2	3	4	5	6	7	8
1	-	**0.707****	0.08	0.116	**-0.273***	-0,157	0.110	0.186
2		-	0.053	0.194	**-0.227***	-0.121	-0.118	0.21
3			-	0.201	0.094	-0,202	-0.191	0,195
4				-	-0.111	-0.140	0,133	-0.084
5					-	-0.097	-0.084	0,213
6						-	0.114	-0.071
7							-	**0.297***
8								-

* p<0.05 ** p<0.001
1 – self-report, 2 – Chuprikov questionnaire, 3 – "Napoleon pose", 4 – "Applause", 5 – "Crossing of fingers", 6 – "Aiming", 7 – "Rozenbakh test", 8 – Dichotic listening

metry, could indicate the existence of intermodal complex with its functional laterality. Thus, this study showed that the test designed to assess one type of asymmetry, in most cases, do not give consistent results, which may indicate the independence of their diagnostic value.

In the course of study, we found a dichotic listening feature that caught our attention. As you know, this technique was proposed by D. Kimura (1961) to determine the leading ear. The fact that the dichotic test reflects precisely the dominant hemisphere for language was confirmed by almost complete coincidence of the results of dichotic tests with the results of Wada tests. Recently it was demonstrated again (Hugdahl, 2005). In our country E.P. Kok, V.S. Kochergina, L.V. Yakusheva (1971) first introduced the dichotic listening technique. Modification used by the majority of local researchers was developed in the laboratory of neuropsychology of the Faculty of psychology of Moscow State University (Kotik, 1974). With all the advantages of this technique, there are some questions on procedures for its implementation. To eliminate the possible influence of technical artifacts after full listen of all the series earphones were reversed. Thus, each subject listened to a set of words twice, first at the initial position of headphones, then – in the reverse. Our study showed that 52% of subjects show the change in sign of the coefficient of the right ear to the opposite in the second series (after turning the headphones). Probably, the subjects in the second series reproduce exactly the words that clearly heard in the first series by the leading ear. Recognizing even part of a word, heard by the non-leading ear in the second series, they conjecture it correctly, based on the image of the word, embodied in the first series due to the leading ear. This means that to accurately determine audioverbal lateralization it is necessary to prevent a repetition of words after turning headphones or simply not to turn the headphones, because the quality

of modern equipment makes it possible to exclude technical artefacts. Despite the fact that the described feature of dichotic listening procedure challenges the results of many studies of the ear asymmetry, it opens up new possibilities for the study of hemispheric interaction. After all, if the recognition of words, applied to the non-leading ear, is based on information received previously by the leading ear, then we are dealing with cerebral comparing of information received by different hemispheres. Thus, knowing the degree of lateralization, as measured by the modified (without repeating the words in the second series) version of dichotic listening, we can then evaluate the hemispheric interaction, using the original version of the method.

Special attention should be paid to mathematical procedures applicable when comparing the asymmetry parameters with the psychological characteristics. This largely depends on whether interhemispheric asymmetry is linearly changed features or there are qualitative differences between right-handers, ambidexters and left-handers. Our researches (Kovyazina, Myachev, Khokhlov, 2012) show that when comparing asymmetry options with psychological characteristics there are relationships that cannot be reduced to a linear dependence, and can be best described by U-shaped functions. In other words, ambidexters are not always the ”middle” between left-handers and right-handers. Apparently, for the number of relations ”type of asymmetry – psychological characteristics” there is a certain asymmetry optimum, that corresponds to the highest values of the investigated psychological characteristic. Such connections are best described by the functions of polynomial regression.

To solve a number of practical problems we shall define a common indicator of interhemispheric asymmetry without definition of functional lateralization of the individual systems. For example, it may be necessary to identify the prevailing cognitive strategies when organizing differential training. To do this, a method based on the achievements of the modern Item-Response Theory (IRT), involving the calculation of tests difficulty, using the logit scale was introduced. Each testing was regarded as one of the items of the test, ”the right answer” was a coincidence with self-report.

The weight of each task is calculated by the formula: ln (p/q), where p – the number of subjects whose results at sampling coincided with the self-report, q – the number of subjects whose results at sampling did not coincide with the self-report. In those samples where it was possible to get one of the three options (right-hander, ambidexter, left-hander), getting the result ”right-hander” or ”left-hander” by ambidexter, as well as getting by right-hander or left-hander the result ”ambidexter”, added 0.5 point both in the numerator and in the denominator. The resulting weight coefficients allowed deducing the formula for calculating the integral index of asymmetry: ”Crossing of fingers” × -0.2513 + ”Napoleon pose” × 0.1252 + ”Applause” × 0.5108 + ”Aiming” × -0.1921 + ”Rozenbakh test” × 0.2907 + ”Chuprikov questionnaire” × 2.8006 + ”Dichotic listening” × 0.5331. Instead of the names of samples, the numbers 1, 0, -1 for the options ”right-hander”, ”ambidexter”, ”left-hander”, respectively should substitute. The results of Chuprikov

questionnaire and the dichotic listening should first be transferred from raw points to the ternary scale using accepted intervals (see above). We obtained the distribution of the integral index of asymmetry with the following parameters: 2,5411±1,9274. It is significantly different from normal and largely confirms the existing notions of the distribution of right-handers, left-handers and ambidexters in the population (see the figure). The tested subjects can be divided into groups of right-handers, ambidexters and left-handers by dividing the x-axis into three equal parts. In this case, the boundary between the left-handers and ambidexters will be equal – -1.2125, and between ambidexters and right-handers – 1.7456. Thus, the left-handers would be 8% of the sample, ambidexters – 10%, and the right-handers – 82%.

The full study of interhemispheric asymmetry and its relation to psychological characteristics is impossible without understanding the role that the functional lateralization of the brain plays in human adaptation to various environmental conditions. In modern neuropsychology there is an opinion that functional brain asymmetry as well as sustainable left hemisphere dominance is a particular feature of the human brain, which appeared in anthropogenesis due to the emergence of speech and dextrism. In our opinion, there is every reason to believe that our distant evolutionary ancestors already had brain asymmetry and the issue here is not in the labor force or in the emergence of speech. Vice versa, brain asymmetry of our evolutionary ancestors Homo sapiens sapiens was the

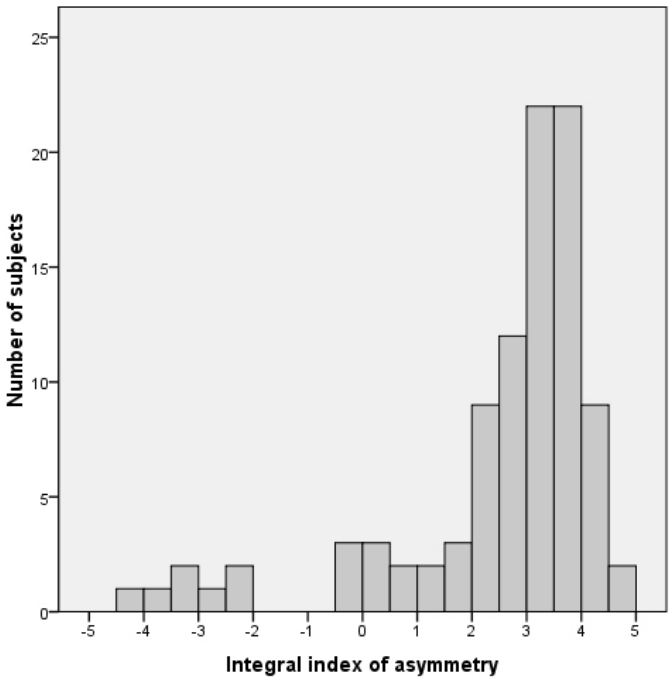

Fig. 1. Distribution of integral index of asymmetry

necessary condition for the development of skills and communication means. Most likely, at its occurrence in the evolution, speech first just used, and only then developed and qualitatively transformed the already existing animal interhemispheric asymmetry. As you know, the asymmetry can be detected already at the molecular level, which allows considering it as a fundamental property of living systems. During the evolution, organisms with different types of symmetry and deviations from it occurred. The creation of basic types of symmetry: spherical, radial, bilateral was mediated by interaction with the environment. Force exposures of environment, primarily due to gravity, were the factors that caused the need to form such a body structure, which provided it with the most complete harmony with the environment. Also, the size of organisms, their capacity for independent movement and a number of other features predetermined the presence of a particular type of symmetry, the evolutionary transition from spherical to the radial symmetric structure and then to the bilateral organization of the body. Evolutionary transformations continued, however, not only in the direction of a balanced structural plan of animals, but also in the direction of asymmetrization. Already in the early stages of evolution, starting with the simplest, in the structure of living organisms there were deviations from perfect symmetry. In most cases, it allowed more effectively adaptation to the needs of the environment and implementing behavioral functions. Radial organisms with multiple symmetry were the dead branch of evolution. Progressive development was usual for bilaterally symmetrical animals with in one form or another functional laterality of the nervous system and the body as a whole. Based on the accumulated data in the literature and the study of the functional asymmetry of animals performed by V.L. Bianki (1985), we can say that the interhemispheric asymmetry is a general property of the brain, characteristic for at least superior vertebrates. A number of review articles (Levy, 1977; Walker, 1980; Andrew, 1983; Geschwind, 1983; Strauss, Kosaka, Wada, 1983) confirm this position.

It seems that evolution was on the way from the symmetrical structure of the body and nervous system to the gradual growth of asymmetry, which allows more efficient survival in the conditions of natural selection. The following rule can be traced: the more specific functional asymmetry is typical for some form, the more complex forms of behavior demonstrate its representatives. As for dextrality, it is a specific norm not for all wildlife, but it is more common than left-handedness. It makes us think that the asymmetry itself is a much more ancient mechanism than its direction, which is largely determined by environmental rather than genetic factors. Following the same logic, one can expect that at some stage in the evolution, dextrality was placed on a genetic level, providing organisms with greater opportunity for survival in dextral oriented environment. Despite evident phylogenetic preconditions to functional asymmetry, the origin of lateralization of purely human functions is still a controversial issue. V.S. Rotenberg (1979, 2001) distinguishes between two opposite ways of information processing, typical for a person and with local attachment to hemispheres. The left hemisphere of all varieties of real and potential links selects few internally consistent, not mu-

tually exclusive, and based on that creates unambiguous context. The right hemisphere ”grasps” reality in all the contrariety and ambiguity of links and forms multi-valued context.

We believe that the need for unambiguous context was the factor that led to the consolidation of dextrality as the species norm. This is directly related to the essential characteristic of human adaptation, which distinguishes it from the rest of the animal world. The whole history of the evolution of hominids was aimed at saving energy and intellectual resources of the brain (Savelev, 2010). Social life provoked the desire to minimize the intellectual efforts. Since the beginning of modern human, in populations of sapiens there is constant strict artificial selection for ”sociality”. The method of external storage and transmission of biologically relevant information occurred; it reduced the role of individual abilities. Such artificial selection started to eliminate individuals with individualized behavior forms, giving reproductive advantage not to the most capable individuals, but to those who could maintain the existing in the group behavioral skills and relationship forms. In our opinion, the development of the left hemisphere was necessary because, according to V.S. Rotenberg hypothesis (1979, 2001), it provided the creation of unambiguous context. Namely, the production of unambiguous signs and symbols contributed to improving of intra-group communication and ensured the maintenance of the social structure of sapiens. This gave rise to hemispheric relations structure that we can see today. Recently, we together with A.I. Lakhmetkina made an experiment the results of which prove this assumption. Using the evaluation method of the integral coefficient of asymmetry, the subjects were divided into two groups that differ in the degree of cerebral lateralization. The group had team games, the success of which depended on the ability to quickly create unambiguous context. Throughout the game time, the group consisting of members with large integral asymmetry coefficients, showed a more effective implementation of the objectives, showing high level of group cohesion and the ability to quickly come to a consensus. Their opponents, in most cases, could not reach a single solution.

In our opinion, the use of the methodological basis of the theory of evolution will allow making a fresh look at the results of hemisphere asymmetry studies. A comparison of the features of adaptation of living organisms at different stages of evolution, with the asymmetry of their nervous system, opens up new possibilities for the interpretation of the relationship between different types of functional asymmetry of the brain with the psychological characteristics of a person.

CONCLUSION

The revision of methodic and methodological problems of functional brain asymmetry in modern neuroscience, we shall point out that the work in this area is far from its completion. It is now clear that methods used in the neuropsychological studies of hemisphere asymmetry have many defects. The dominant concept of the independence of manual, audioverbal and visual fields is likely to be

significantly changed in the near future. As long as there is no effective method of non-invasive diagnosis of functional asymmetry, the reliability of which will be confirmed by neuroimaging studies and mathematical modeling, we have to use the existing tests. However, we shall each time specify the particularities of diagnosis and consider the results of tests separately to avoid mixing of variables. The addition of the results of tests is only possible at the administration of empirically derived weight coefficients. The method of evaluation of the integral index of hemisphere asymmetry, proposed in this paper, can be used to divide subjects into groups according to the degree of functional lateralization of the brain, for example, at the organization of differential training and staff selection.

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PRIMING EFFECTS IN INDIVIDUALS WITH CORPUS CALLOSUM PATHOLOGY

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SUMMARY

Background: One of the methods that allow us to investigate the lateral organization of involuntary memory is priming. Originally this method was developed as a way to examine visual perception and visuomotor coordination in a cognitive paradigm. Eventually, however, it became clear that the capabilities of priming are much broader. Among other things it provides a unique possibility to examine involuntary memory in subjects with corpus callosum pathology (CCP), since it allows stimuli to be presented in different visual hemifields. The aim of our study was to identify and analyze the contribution of interhemispheric interaction in the work of involuntary memory.

Material/ Methods: In our study we examined 52 normal subjects and 16 subjects with CCP, using the method of priming.

Results: We discovered that in normal subjects there was a significant correlation between reaction time (RT) and priming. In the case of a relevant prime, RT decreased; in the case of an irrelevant prime, RT increased. We also discovered that in conditions with no priming, the right hemisphere reacts faster than the left. In subjects with CCP we observed priming system impairment: RT increased when the experimental conditions required interhemispheric interaction.

Conclusions: Our experiment demonstrated that the corpus callosum has a major influence on the process of selectivity in involuntary memory and learning, and in normal subjects distributes the energy between the brain hemispheres, suppressing the subdominant hemisphere in the present activity, thus forcing interhemispherical asymmetry.

Key words: bilateral asymmetry, interhemispheric interaction, involuntary memory

INTRODUCTION

Split Brain Syndrome, as described in neuropsychology, includes impairments of perceptual and motor activity, more specifically impairments in the coordination of motor responses in bimanual task,s as well as in perception, speech and spatial perception (Gazzaniga, 2004; Moskovitchute, Simmernitskaya, Smirnov & Filatov, 1982; Khomskaya, 2007). Since there are distinct lateral differences in memory impairments, we can assume that different aspects of memory activity are variously lateralized. The fact that memory is a complex holistic integrative activity means that our brain needs a mechanism of interaction of left-and right-brain functions. We can logically assume, then, that the corpus callosum plays a role in the integration of memory processes, and that if CCP occurs, the whole memory system suffers, since the corpus callosum connects all cortical sections of the left and right hemispheres.

There is little data, however, regarding the specific nature of memory impairments in cases of corpus callosum pathology (CCP; Simmernitskaya, 1989; Guise et al., 1999; Mayers & Sperry, 1985; Zaidel & Sperry, 1974). On the one hand, this lack of evidence can be explained by the instability of the symptoms (Clark & Geffen, 1989; Gazzaniga, 2000). On the other hand, studies of CCP are traditionally focused on the measurement of the voluntary aspect of mental activity. In these studies, several authors have noted the similarity of symptoms of CCP and right hemisphere damage (RHD; Buklina, 2004; Kovyazina & Balashova, 2009). We can assume, moreover, that specifically involuntary processes (lateralized in the right hemisphere) are the first to suffer in patients with the loss of interhemispheric connectivity based on CCP. Symptoms in this case are more stable because of the lack of compensation. Thus it is exactly the involuntary memory system that is the most vulnerable in case of CCP.

Involuntary memory is the individual's ability to store, retain, and recall information and experiences without conscious effort (Falikman & Koyfman, 2005). Involuntary memory (compared with voluntary) is an automatic process, and is characterized by a high rate of processing speed, a lack of flexibility, and a lack of conscious awareness (Gippenreiter & Romanov, 2000; Falikman & Koyfman, 2005). It mostly consists of perception and motor skills. Neuroimaging studies demonstrate that voluntary and involuntary memory involves fundamentally different structures, which function almost independently (Buckner et al., 1996).

The involuntary level of memory activity includes skills, which are the consequence of automatic, repeated, stereotyped and unconscious actions, as well as priming effects.

Learning in psychology is traditionally described as the process of acquiring changes of the individual's cognitive and behavioral patterns in accordance with previous experience. The learning ability of the brain (the ability to develop new skills) is connected with neuroplasticity (the ability of the human brain to change as a result of one's experiences). The most studied phenomenon here is the plasticity of the primary sensory and motor cortex (Grunwald, 2008). The corpus

callosum, which is responsible for the integrative activity of the brain hemispheres and the interhemispheric transfer of information, supports the normal functioning of the motor sphere and perception systems, and hence influences sensorimotor learning. Therefore, symptoms of CCP occur primarily in the sensorimotor area (Korsakova, 2007).

Another subsystem of involuntary memory, besides sensorimotor learning, is the perceptual subsystem, which traditionally includes priming effects. The priming effect is a change in the velocity and accuracy of a reaction after the presentation of information, which is connected with the content or context of the task, but not directly correlated to its purpose and requirements. Priming effects can also be observed in the increased probability of spontaneous retrieval of this information in suitable conditions (Falikman & Koyfman, 2005). There are different types of priming (on several grounds):

- emotional and cognitive;
- conscious and unconscious;
- perceptual and semantic (perceptual coding is based on the resemblance of objects, and semantic coding includes semantic categorization of objects).

Studies of the interhemispheric transfer of involuntary memory traces in the situation of unconscious priming in normal subjects with intact brain commissures have revealed that reaction time (RT) does not change between the ipsi- or contralateral presentation of prime and target (Reynvoet, Ratinckx & Notebaert, 2008). RT decreases when prime and target are relevant and increases if they are not. Studies of emotional priming have discovered that emotionally intense words, presented subliminally, influence RT in positive and negative targets. The most rapid responses have been observed in the case of emotional congruity between primes and targets. However, subjects with a high level of anxiety significantly slow down after the presentation of subliminal, emotionally negative priming (Hermans, Spruyt, De Houwer & Eelen, 2003).

Similar studies have been conducted with subjects with ACC or childhood collosotomy (Forget, Lippe & Lassonde, 2009). These investigations demonstrate the lack of interhemispheric transfer of information pertaining to subliminal perception. Ipsilateral priming effects were no different from control subjects.

There is, then, impairment of the interhemispheric transfer of involuntary memory traces in CCP. It remains to be determined, however, traces cannot be transferred.

The purpose of our study was to identify and study the contribution of interhemispheric interaction in the work of involuntary memory.

MATERIAL AND METHODS

The experimental group consisted of 11 patients with CCP of various origin (full or partial agenesis of the corpus callosum, hypoplasia of the corpus callosum, dysgenesis of the corpus callosum, atrophic processes, tumors, or vascular lesions). The oldest experimental subject was 73 years old, the youngest was 9.

The control group consisted of 43 healthy, normal right-handed subjects. The oldest was 53 years old, the youngest was 17.

The experiment was conducted during standard clinical neuropsychological examinations. The subjects with CCP demonstrated a tendency to unilateral spatial neglect and other spatial errors. In the tactile sphere, we could observe single anomy errors. There were insignificant difficulties in performing a bimanual reciprocal task in praxis (mostly in the left hand) and difficulties in switching the pose of the fingers without visual control. There were also some unspecific impairments in voluntary memory in situations with interference.

In our experiment we presented the subjects with two photos in the left or right visual field. The subjects had a task of binary classification: if they saw a photo of the first person, they had to push the right button on the keyboard, while if they saw a photo of the second person, the left. Target presentation was preceded by short subliminal presentation (5 ms) of the same or different photo (relevant or irrelevant prime). There was also a series of control trials without any priming at all. In the center of the screen there was a fixation point.

Every trial went the same way. There was 5 ms of priming (or just a dark screen in trials without priming). After a 500 ms pause (dark screen) there was a 1500-ms presentation of the target, to which the subject reacted as instructed. The trial ended with a 1000-ms pause.

We composed the stimuli in pairs (prime – target), which differed in the following respects:

- presence or absence of priming;
- relevancy or irrelevance of the prime;
- the visual field of prime and target presentation:
- prime and target appear in the right visual field;
- prime and target appear in the left visual field
- prime appears in the right, and target in the left visual field;
- prime appears in the left, and target in the right visual field.

Thus there were 20 different pairs of stimuli, each of which was presented to the 20 times in random order. The experiment lasted 21.5 minutes.

We analyzed only correct responses. We got 400 RTs for each subject, divided into 10 groups of answers:

1. no priming, target on the left;
2. no priming, target on the right;
3. relevant prime on the left, target on the left;
4. relevant prime on the left, target on the right;
5. relevant prime on the right, target on the right;
6. relevant prime on the right, target on the left;
7. irrelevant prime on the left, target on the left;
8. irrelevant prime on the left, target on the right;
9. irrelevant prime on the right, target on the right;
10. irrelevant prime on the right, target on the left.

The results from each group were compared with each other using the non-parametric Mann-Whitney test.

RESULTS

The results from the control group were as follows:

1. In the absence of priming (conditions 1 and 2) the RT was significantly shorter in the case of a target in the left visual field (U = 645, p = 0.001).
2. In all cases of relevant prime (conditions 3-6), there was significantly shorter RT as compared to no priming and target on the same visual field (3: U = 532, p = 0.014; 4: U = 551.5, p = 0.001; 5: U = 612, p = 0.002; 6: U = 584, p = 0.02).
3. In all cases of irrelevant prime and target (conditions 7-10) there was significantly increased RT compared to no priming and target on the same visual field (7: U = 519, p = 0.002; 8: U = 481, p = 0.011; 9: U = 602, p = 0.001; 10: U = 575, p = 0.004).

Thus there was a significant correlation in control subjects between RT to the target and priming. In the case of a relevant prime, RT decreased. In the case of an irrelevant prime, RT increased. We also discovered that in conditions with no priming, the right hemisphere reacted faster than left.

The patients with CCP (the experimental group) demonstrated the following when performing the experimental tasks:

1. In trials without priming (conditions 1-2), the subjects with CCP demonstrated no significant differences between the trials with target presented in the left and right visual field, due to the increased RT of the left hemisphere(U = 113, p = 0.625). In both conditions 1 and 2 RT did not significantly differ from the normal RT (1: U = 72, p = 0.315; 2: U = 108, p = 0.571). Although there was a tendency in condition 2 (no priming, target on the right) to decreased RT compared with normal RT, this was caused by reduced hemispheric asymmetry in RT in cases without priming in the subjects with CCP. This fact can be explained by assuming that in the case of impairment of interhemispheric interactions, the right hemisphere ceases to suppress the left, and so the left hemisphere shows increased activity. Thus, normally the corpus callosum performs the function of distributing activity between the hemispheres, which is necessary in order for the dominant hemisphere to suppress the subdominant.
2. In the trials in which prime (whether relevant or irrelevant) and target were presented in the right visual field (conditions 5 and 9), we observed a significant decrease of RT in comparison with the condition 2 (target on the right, no priming; 5: U = 66.5, p = 0.035; 9: U = 85, p = 0.007). Thus the left hemisphere cannot distinguish primes properly, but it detects the formal presence of priming and categorizes any priming as correct. Because of the fact that the left hemisphere is dominant in conscious processes, it can tell (fixate) the presence of priming (i.e. determine that there is an image that flashes before the target), still, it cannot tell specifically which particular prime was presented, because the right hemisphere is dominant in the processing of unconscious

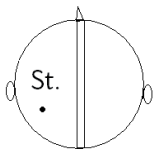
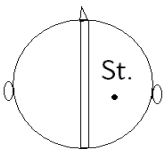
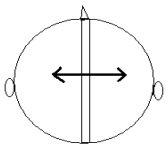
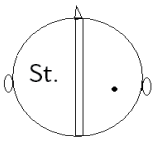
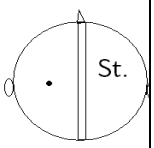
information. The left hemisphere, isolated from the right, is able to learn (acquire a skill) on the basis of the formal presence of priming: a relevant prime is assessed as proper, and an irrelevant prime is underestimated. We should also note that in condition 9 (irrelevant prime and target, both on the right) there is decreased RT compared with normal results ($U = 124$, $p = 0.023$). In condition 5 (relevant prime and target, both on the right) there were no significant differences from normal results ($U = 154$, $p = 0.587$). Thus the left hemisphere reacts properly to the presence of a relevant prime by decreasing RT (it begins to act normally). However, in the case of irrelevant priming, the left hemisphere reacts the same way: RT decreases to the level of relevant priming. In the control group, in all cases including irrelevant primes and targets, we observed increased RT compared with no-priming trials. In other words, in the case of irrelevant priming, much more time is needed for the comparison of prime and target and the inhibition of the wrong reaction. In the case of CCP this does not happen. Such responses from the left hemisphere in subjects with CCP can be called impulsive, and such answers can be observed in clinical neuropsychology in pathology of the basal prefrontal lobes; they are also considered symptomatic of impairment in the neurodynamics of mental activity, including also memory.

3. When primes (whether relevant or not) and targets are presented in the left visual field (conditions 3 and 7) there were no significant differences between condition 1 (no priming, target in the left) (3: $U = 65$, $p = 0.427$; 7: $U = 102$, $p = 0.675$). Thus the RT of the right hemisphere, isolated from the left, was not different from RT with no priming in subjects with CCP and in normal controls. The right hemisphere ignores the presence of priming. The RT does not show any learning. But such indifference to the very presence of priming itself can be connected with the fact that in normal interhemispheric interaction the left hemisphere is dominant for the fixation of memory traces (which is confirmed by the left hemisphere RT, which fixated the presence of priming, but did not process its content). The right hemisphere, in cases of CCP, cannot fixate the memory traces on its own, which is why it acts exactly as thought there were no traces at all. In other words, we can speak of a tendency to left unilateral neglect, on the involuntary level of memory activity, caused by the impairment of interhemispheric interactions. Another explanation may be that even if the isolated right hemisphere can fixate involuntary memory traces, they are quite incapable of influencing current activity (reacting to the target). Either way, then we observe impairment of the work of the involuntary memory system.
4. In all trials, when prime and target, whether relevant or not, were presented in contralateral visual fields (conditions 4, 6, 8, 10), we observed increased RT compared with conditions 1 and 2 (no priming) (4: $U = 56$, $p = 0.024$; 6: $U = 107$, $p = 0.007$; 8: $U = 40$, $p = 0.016$; 10: $U = 23$, $p = 0.01$). In all these conditions the influence of interhemispherical interactions on reaction increases, and we can analyze the variability of this impact compared with normal subjects. The difference depends not only on the slowdown of RT

(compared with normal subjects and conditions 1 and 2), but also with the fact that both hemispheres fail to react properly to any priming. In fact, the hemispheres do not "see" relevant priming. On the one hand, the brain notices the differences (and this matches conditions 5 and 9); on the other hand, these differences do not automate and do not lead to learning (which matches conditions 3 and 7). Irrelevant primes are estimated correctly and relevant primes are overestimated. This situation can be seen as compensatory, with the participation of both hemispheres in the process of reaction. The right hemisphere cannot ignore the presence of priming, as it appears in the case of the hemispheres functioning in isolation, because the left hemisphere fixates the presence. The left hemisphere cannot ignore the content processing of the right hemisphere, which interferes with building formal skills (such as reacting only to the presence of priming). But in subjects with CCP, the transfer of information about the presence and content of the stimuli occurs through compensatory paths (subcortical structures and anterior commissure), which significantly slows down the work of involuntary memory, and in the case of rapid activity does not allow the skill to form. In every case, the prime processes as irrelevant, which leads to decreasing the probability of error. Thus, compensation goes in the direction of rejecting the automatic, rapid, inflexibile unconscious processes in favor of more energy-intensive ways of reaction.

Thus our experiment demonstrated that the corpus callosum performs the function of distributing energy between the brain hemispheres, and suppresses the subdominant hemisphere in the present activity, forcing interhemispherical asymmetry, by suppressing the identical process in the subdominant hemisphere. The corpus callosum also significantly influences the process of selectivity in involuntary memory and learning.

Table. 1. The main results of the study

Variants of presentation («St.» – stimulus; «·» – prime)	 8, 4	 6, 10	  7, 11	 5, 9
Control group	In the case of a relevant prime, RT decreased. In the case of an irrelevant prime, RT increased.			
Patients with CCP (experimental group)	Any prime perceived as relevant.	Not seen any prime.	Any prime perceived as irrelevant.	Any prime perceived as irrelevant.

To further clarify these results it would be useful to match our experimental data with data obtained from groups of subjects with unilateral local brain lesions, i.e. patients with pathology of the right and left hemispheres.

DISCUSSION

The group of patients with pathology of the CC and right and left hemispheres of brain have the same response to non-verbal visual stimuli. In this case we can speak about leveling the differences between the hemispheres, by increasing the time of reaction of the left hemisphere of the brain (at the level of critical importance). This may be the evidence of the fact that the left hemisphere is no longer to endure the inhibitory influence from the right hemisphere (see also Nikolaenko & Pachalska 2008; Pachalska et al 2008). In all conditions which require the transfer of information between the hemispheres of the brain, we can notice a significant increase in time of reaction in the experimental group, regardless of whether stimuli are congruent or not. In healthy subjects, this dependence is clearly discernible. This may indicate the decrease in efficiency and hemispheric interaction. Normally, the CC realizes a redistribution of activity between the hemispheres of the brain and has an inhibitory effect on the activity in the subdominant hemisphere, increasing interhemispheric differences and suppressing an identical process in the next hemisphere. The experiment showed an abnormality of the priming effect in patients with dysfunction of hemispheric interaction.

CONCLUSIONS

Our experiment demonstrated that the corpus callosum has a major impact on the process of selectivity in involuntary memory and learning, and in normal subjects distributes the energy between the brain hemispheres and suppresses the subdominant in the present activity, forcing interhemispherical asymmetry.

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MEMORY IMPAIRMENT IN DEMENTIA WITH LEWY BODIES RELATIVE TO ALZHEIMER'S DISEASE AND PARKINSON'S DISEASE WITH DEMENTIA

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SUMMARY

Background: The cognitive profiles of patients with dementia with Lewy bodies (DLB) and Parkinson's disease with dementia (PD-D) are quite similar, though different from Alzheimer's disease. However, studies comparing the memory performance of patients with DLB, PD-D and AD are rare.

Material/ Methods: Patients with DLB, AD and PD-D – matched for general cognitive status – were compared on a range of memory measures. Semantic memory, verbal fluency and verbal learning were assessed.

Results: Delayed verbal recall was better preserved in DLB and PD-D than AD. Semantic memory was better preserved in PD-D than AD. Neither letter nor category fluency differentiated between the groups.

Conclusions: Our study shows the usefulness of the Auditory Verbal Learning Test (AVLT) as an easily administered verbal learning measure for further research assessing episodic memory in DLB in comparison to PD-D and AD.

Key words: episodic memory, semantic memory, learning

INTRODUCTION

Dementia with Lewy bodies (DLB) is a relatively new clinical concept. The key features of DLB include:

- fluctuating cognition;
- visual hallucinations;
- parkinsonism.

Suggestive features include:

- low dopamine transporter uptake in basal ganglia in SPECT/PET scan;
- REM-sleep behavior disorders;
- hypersensitivity to neuroleptics.

Among the supportive features are:

- repeated falls and syncope;
- transient, unexplained loss of consciousness;
- severe autonomic dysfunction, such as orthostatic hypotension;
- urinary incontinence;
- hallucinations other than visual;
- systematized delusions;
- depression;
- relative preservation of medial temporal lobe structures on CT/MRI scan;
- generalized low uptake on SPECT/PET perfusion scan with reduced occipital activity;
- abnormal (low uptake) MIBG myocardial scintigraphy;
- prominent slow wave activity on EEG with transient sharp waves in the temporal lobes (McKeith 2005).

In clinical practice it is particularly important to achieve a differential diagnosis between DLB, Parkinson's disease with dementia (PD-D) and Alzheimer's disease (AD), as some medications may be harmful for DLB patients (e.g. neuroleptics); also, parkinsonism can be succesfully treated with levodopa, while dopamine agonists should be avoided (they may trigger psychosis and hypotension).

The differential clinical diagnosis of DLB and PD-D can be difficult due to the overlap of the symptomatology. DLB and PD-D have many common motor, cognitive, and psychiatric features. The neuropathological evidence also suggests that both conditions are part of the same clinical spectrum (Jelinger 1996, Jelinger 2009, Tsuboi et al. 2007). DLB is differentiated from PD-D by time criterion. If the patient with Parkinson's disease (PD) develops dementia later than one year after the onset of motor symptoms, he/she is then diagnosed with PD-D. If parkinsonism and cognitive impairment appear simultaneously or if cognitive decline precedes the onset of motor symptoms, the patient is diagnosed with DLB.

The cognitive profile of DLB differs from amnestic Alzheimer's disease (AD). DLB patients present with earlier and more profound attentional, executive and visuoperceptual impairments than amnestic AD patients. The visuoperceptual deficits observed in DLB may be similar to those observed in a visual variant of AD (posterior cortical atrophy, PCA), although PCA patients present with more focal symptoms (e.g. visual agnosia, color agnosia, hemianiopsia). In spite of quantitative differences between DLB and amnestic AD, these deficits and cognitive fluctuations in DLB pa-

tients may be reflected in different qualitative patterns of neuropsychological task performance in DLB compared with AD (Doubleday 2002). Memory deficit is regarded as specific for AD, while dysexecutive syndrome and visuospatial impairment are specific for DLB and PD-D (Shimomura et al. 1998, Simard et al. 2000, Collerton et al. 2003, Metzler-Baddeley 2007, Oda et al. 2009, Pąchalska & Łukaszewska 2011). Moreover, a study by Simard et al. (2002) showed that working memory was more impaired in DLB than in AD, while AD patients had more deficient verbal episodic memory.

Comparative studies analyzing memory function in PD-D, DLB and AD are rare. Only two studies - in which patients were matched in terms of cognitive status - have compared episodic memory in AD, DLB and PD-D patients. Patients with DLB and PD-D had memory scores superior to those of AD patients on the Dementia Rating Scale (DRS) (Aarsland et al. 2003). A similar pattern of results was noted by Noe et al. (2004) for verbal material in the Buschke Selective Reminding Test (BSRT). However, DLB patients performed worse on the visual memory measure in the same study. There is evidence that patients with DLB perform better than patients with AD in verbal recall tests (Noe et al. 2004, Simard et al. 2002). It has been suggested that memory impairment in DLB results from defective encoding as a consequence of a slowed learning process, rather than a consolidation deficit (Hamilton et al. 2004). In DLB and PD-D patients have problems with spontaneous retrieval of information without significant loss after a delay, as evidenced by improvement in the delayed recognition trials (Tröster 2008). Problems with delayed free recall but not recognition tasks are consistent with the type of fronto-striatal dysfunction connected with DLB, compared to the hippocampal atrophy associated with AD (Crowell et al. 2007). Poor learning results may sometimes stem from working memory impairment (see Metzler-Baddeley 2007) and / or defective encoding (Goldmann et al. 2008).

In this study we compare the verbal learning profile in DLB to PD-D and AD patients. To our knowledge this is the first attempt to analyze verbal learning of unstructured material with a straightforward procedure, unlike the one from BSRT. It was assumed that AD patients would have major difficulty in delayed recall, while DLB patients would present with the greatest number of intrusions. Ours is also the first study comparing semantic memory in DLB, PD-D and AD. We hypothesized that semantic memory scores would not differentiate between the groups. The identification of different memory pattern in the results of neuropsychological tests would be valuable in the differential diagnosis of AD, DLB and PD-D.

MATERIAL AND METHODS

Patients

We studied 13 DLB patients, 13 patients with probable AD, and 18 patients with PD-D, who volunteered for the study. Dementia with Lewy bodies was diagnosed according to the improved diagnostic criteria of the third report of the DLB Consortium, published in 2005 (McKeith et al. 2005). All the DLB patients met the criteria for probable DLB. Alzheimer's disease was diagnosed based on the diagnostic criteria of the DSM-IV (Wciórka 2008). PD was diagnosed according to the Parkinson's

Disease United Kingdom Brain Bank criteria (Gelb 1999, Hughes 1993). As current diagnostic criteria for PD-D were published in 2007 (Emre 2007) and the study was conducted in 2004-2005, PD-D was diagnosed according to DSM-IV (Wciórka 2008). All groups were matched for age, years of education, and global cognitive performance (Mini-Mental State Examination) (see: Table 1).

Clinical Diagnostic Criteria

In all patients, a neurological examination was accompanied by a structured interview with the caregivers. All these patients received magnetic resonance imaging to exclude focal brain lesions. PD-D patients were tested in the "on" phase. DLB patients were not examined during a period of marked confusion.

Our neuropsychological assessment included the Mini-Mental State Examination (Folstein et al. 1975) to match the patients for general cognitive impairment. Semantic memory was assessed by Information and Vocabulary subscales from Wechsler Adult Intelligence Scale-Revised (Brzeziński et al. 2004). Verbal fluency was tested by means of letter ("K") and semantic ("animal") 60-second fluency trials (Lezak 2004). Verbal learning was assessed with the 15-word Auditory Verbal Learning Test (AVLT) (Choynowski & Kostro 1980, Lezak 2004). AVLT is the most popular verbal learning measure, but it has never been used to assess this parameter in DLB, AD and PD-D. In contrast to the BSRT (used by Noe et al. 2004), the test procedure in the AVLT is easy, and test performance relies less on cognitive control and working memory, and more on the episodic memory that it is supposed to test. Additionally, Ferman et al. (2006) indicated that the AVLT percentage retention, in conjunction with the results of the TMT A, the BNT, and the "copy" test of the Rey-Osterrieth Com-

Table 1 Demographic data

	1 DLB (n=13)	2 AD (n=13)	3 PDD (n=18)	F	p
age at the time of the assessment (yr)	73.77 (4.46)	75.00 (8.24)	71.67 (3.27)	1.69	0.20
gender (male), n(%)	5(38%)	7 (54%)	12 (67%)	-	-
education (yr)	10.54 (3.23)	10.00 (4.74)	9.28 (4.07)	0.39	0.69
number of years since the subjective onset of symptoms	2.15 (1.91) [1-3]	1.25 (1.66) [2-3]	9.00 (4.19) [3-1,3-2]	30.10	<0.001
MMSE	16.92(6.56)	15.31(6.18)	19.06 (4.49)	1.69	0.20
age at onset	71.62 (4.86) [1-3]	73.92 (8.20) [2-3]	62.67 (4.41) [3-1,3-2]	16.14	<0.001

Values are expressed as mean (SD), unless otherwise indicated
The significant intergroup differences are indicated in brackets

plex Figure, is a highly sensitive and specific instrument for the differential diagnosis of DLB and AD. Three AVLT scores were computed: the number of words repeated in all trials, the number of intrusions, and the percentage of information lost over a 10-minute delay. Motor function was assessed by the Finger Tapping Test from the Halstead-Reitan Neuropsychological Assessment Test Battery (Kądzielawa 1990).

Statistical procedure

For group comparisons, parametric data were analyzed by Student's t test and one-way analysis of variance (ANOVA) with Scheffe's or Tamhane's TS post hoc tests. A significance level of $P<0.05$ was used in all comparisons.

RESULTS

Demographic characteristics and dementia severity

All groups were matched in terms of age, education and general cognitive impairment (MMSE), as shown in Table 1. The disease duration was much longer in PD-D patients than in DLB and AD, which is consistent with the late onset of dementia in the course of the disease.

Neuropsychological findings

AD group had lower Information Scores than the PD-D group (see Table 2), but the difference between AD and DLB was not statistically significant. Neither the Vocabulary score, nor category fluency, nor letter fluency differentiated among the groups. Delayed recall in AVLT was more deficient in AD patients than in the DLB and PD-D groups. The difference in immediate recall scores did not reach statistical significance. DLB patients generated the highest number of intrusions in AVLT, but the difference was statistically nonsignificant, as proved by Tamhane's TS post hoc test. Motor speed was higher in AD than in DLB and PD-D patients.

Table 2 Cognitive assessment results

Test (range)	DLB (1)	AD (2)	PDD (3)	F	p
Information (1-19)	**6.67 (2.02)**	**4.54 (2.93) [2-3]**	**7.78 (2.84) [3-2]**	**5.60**	**0.01**
Vocabulary (1-19)	7.50 (3.96)	4.67 (3.92)	7.71 (2.91)	2.95	0.07
category fluency	7.69 (3.99)	7.54 (4.05)	9.89 (4.23)	1.63	0.21
letter fluency	4.46 (2.63)	6.00 (3.03)	4.17 (1.33)	1.50	0.24
AVLT sum of 5 trials (0-75)	21.50 (11.97)	14.15 (8.14)	22.17 (8.08)	3.14	0.05
AVLT sum of intrusions	16.50 (16.78)	5.92 (4.77)	6.89 (7.63)	4.01	0.03
AVLT loss of information following a delay	**39.51 (23.95) [1-2]**	**84.34 (26.54) [2-1,2-3]**	**55.84 (26.64) [3-2]**	**9.73**	**0.0004**
Finger tapping test (T)	**18.75 (11.79) [1-2]**	**33.04 (17.38) [2-1,2-3]**	**18.58 (10.08) [3-2]**	***5.29***	***0.01***

AVLT- Auditory Verbal Learning Test
Values are expressed as mean (SD), unless otherwise indicated
The significant intergroup differences are indicated in brackets

DISCUSSION

Impairment of working and episodic memory is quite common in DLB (Metzler-Baddeley 2007, Simard et al. 2000). However, as explained by Metzler-Baddeley (2007), the interpretation of memory impairment in DLB is difficult, since perceptual, attentional and executive deficits may be interfering with the encoding or retrieval of information and, as a consequence, contribute to lower memory scores. Thus abnormal memory scores may not reflect true memory deficits, but other cognitive problems. Moreover, the assessment of memory in DLB may be significantly obscured by cognitive fluctuations.

In our study, immediate recall was not significantly poorer in AD than in the DLB and PD-D group. This suggests quite similar immediate recall deficits in AD and DLB. However, the observed trend towards statistical significance – lower scores in DLB – was in accordance with Noe et al.'s results (2004). In DLB, initial encoding is compromised by the attentional problems, which is observed in immediate recall results. However, a small part of the information is usually successfully encoded, and can be recalled in a delayed recall task (Lambon-Ralph et al. 2001; Bidzan et al. 2012).

As expected, delayed recall was most deficient in the AD group, which is consistent with previous observations (Noe 2004, Aaarsland 2003, Calderon 2001) and the specificity of the amnestic AD variant, which is characterized by profound episodic memory impairment with significant loss of information over delay (Stopford 2008).

Semantic memory impairment, present in both AD and DLB, is not a key feature of any of these disorders. No semantic memory differences between DLB and AD patients were identified in our study, which is in accordance with previous findings (Calderon 2001, Lambon-Ralph et al. 2001; cf. Metzler-Baddeley 2007). It is worth noting that in Lambon-Ralph et al.'s study (2001), DLB patients were characterized by more severe semantic deficits for pictures than words, which may stem from the overlap of semantic and visuoperceptual impairment.

Neither letter nor category fluency differentiated between the groups in our study, which is in accordance with the results obtained by Noe et al. (2004). Other studies have shown that DLB patients' performance is lower than AD patients' performance on letter fluency (Calderon et al. 2001, Lambon-Ralph et al. 2001, Won Park et al. 2011), which may be due to executive impairment. Patients with various neurodegenerative diseases may achieve similar results on verbal fluency trials because of different deficits. Category dysfluency in AD is mainly the effect of semantic impairment (see Levy et al. 2002), as evidenced by problems with clustering (Tröster et al. 1998, Tröster 2008, Troyer et al. 1998), while PD patients have problems with semantic retrieval (cf. Levy et al. 2002) and difficulties with switching from one subcategory to another (Tröster et al. 1998, Tröster 2008).

In our study, the patients with DLB had the largest number of intrusions in the memory test, although the difference was not statistically significant. It was demonstrated that DLB patients present with an overall tendency to intrusions during the testing and interview, which is a differentiating qualitative feature between AD and DLB (Doubleday et al. 2002). The difference in our study may not have reached statistical significance because we analysed only the intrusions occurring during the verbal learning task.

It is worth mentioning that no significant differences between the patients with DLB and PD-D were identified in our study, which is consistent with previous studies (cf. Metzler-Baddeley 2007). The clinical and neuropsychological characteristics can be similar in PD-D and DLB. This confirms that the PD-D and DLB syndromes constitute a continuum of Lewy body disease, rather than distinct disease entities (Janvin et al. 2006).

Additionally, differences were identified in our study between DLB, PD-D and AD patients in the finger tapping test, which is in accordance with previous findings (Gnanalingham 1997). The differences result from the bradykinesia characteristic for PD-D and DLB patients.

Our study has several limitations. To begin with, the sample sizes were small. Semantic memory was tested only in the verbal domain, which may have influenced the results. Only verbal memory was tested, and the testing procedure did not include a recognition trial to differentiate between retrieval and encoding/storage deficits. What is more, our study focused only on the quantitative measures, and did not take into account the qualitative features of the patients' performance, which may be of utmost importance (Doubleday 2002).

CONCLUSIONS

Our study shows the utility of AVLT as an easily administered verbal learning measure for further research to assess episodic memory in DLB in comparison to PD-D and AD. It is likely that analysis of intrusions, in combination with cognitive control assessment, could shed light on memory impairment in DLB.

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C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

APRAXIA RESEARCH: RUSSIAN AND MODERN NEUROCOGNITIVE TRADITIONS

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SUMMARY

Three scientific traditions of apraxia research are examined in this article: Luria's theory of the systemic structure and dynamic localization of higher mental functions, Bernstein's level theory of motor acts, and the neurocognitive approach. The apraxia classification developed by Luria, the classification of movements widely discussed in neurocognitive tradition, and Bernstein's level structure of the motor act are presented schematically. The strengths and limitations of each of these scientific schools are discussed. The principles of apraxia assessment in Luria's and the neurocognitive framework are analyzed. We conclude that Luria's approach and the neurocognitive tradition of apraxia investigation are quite similar. Bernstein's ideas were formed more than fifty years ago, but seem insightful and fruitful today. According to Bernstein, voluntary movements have some essential features that are not currently taken under consideration. From his point of view, movements are meaningful (determined by a motor task), holistic, hierarchic, dynamic and creative. These postulates were discussed in many of his now-classic works. At the same time we must confess that they are not widely known among clinicians. That is why we believe that Bernstein's concepts can significantly enrich our knowledge in the neuropsychology of praxis.

Key words: Luria, Bernstein, neurocognitive models of praxis, apraxia assessment, level theory of motor acts

LURIA'S THEORY OF PRAXIS

Modern Russian neuropsychology uses the classification and methods of apraxia diagnosis developed by A.R. Luria in the framework of his theory of the systemic and dynamic localization of higher mental functions (HMF). In Luria's work "The motor analyzer and the problem of organizing cortical movement" (Luria, 1957), four forms of manual apraxia are described. Luria demonstrated that "the cortical terminus of the motor analyzer presents as a complex system of zones in the human brain, which carry out specific functions in the organization of the motor act" (Luria, 1957, p.8). The idea of the systemic, multicomponent structure of the cortical terminus of the motor analyzer, where each area plays a particular role in the organization of movement and provides separate components of motor act, was brought forward. The cortical terminus of the motor analyzer includes not only the anterior central gyrus, but also the secondary fields of the inferior parietal cortex, the parietal-temporal-occipital, premotor and prefrontal areas of the cerebral cortex. According to Luria, various types of apraxia develop due to lesions in these areas.

Manual kinesthetic apraxia occurs with damage to the inferior parietal cortex. The mechanism of this type of apraxia is based on kinesthetic reverse afferentation disorder (a disorder of the analysis and synthesis of kinesthetic impulses), when movement cannot be regulated correctly. When this type of apraxia occurs, the patient's movements become dysregulated and undifferentiated; there is a search for the correct posture, and postures change to kinesthetically similar ones. This disorder becomes especially clear when the patient does not receive visual feedback from the performed movement (Luria, 1969b). With left hemisphere lesions, manual kinesthetic apraxia develops bilaterally; with lesions in the right hemisphere, disorders develop mostly in the left hand (Luria, 1957, 1969b, 2002; Korsakova & Moskovichute, 2003; Chomskaya, 2007).

In *manual kinetic apraxia,* the main disturbance is the disintegration of serial movement organization, which disrupts the analysis and synthesis of movements in time. In other words, the process of switching between postures is disturbed, producing a disorder in the sequential change of motor acts. The patient cannot inhibit the previous movement's elements and switch to new ones (it presents as elementary perseveration when the movement continues uncontrollably). That is why complex motor skills disintegrate. This type of apraxia emerges with lesions to the premotor areas of the left hemisphere of right-handers, and mostly develops in both hands (Luria, 1957, 1969b, 2002; Korsakova & Moskovichute, 2003; Chomskaya, 2007).

The leading problem in the *spatial form of apraxia* is the disintegration of spatial analysis and synthesis, leading to a dysfunction of the spatial organization of movement. Patients have difficulties in performing space-oriented movements, and in distinguishing left and right or up and down. Increasing visual control does not facilitate the performance of movements. This form of apraxia develops because of lesions to the TPO area (Luria, 1957, 1969b, 2002; Korsakova & Moskovichute, 2003; Chomskaya, 2007).

The last form of apraxia distinguished by Luria is *regulatory apraxia*. The main symptoms here are problems in the programming, voluntary regulation and control of movement. Patients have disorders in purposeful actions, and usually cannot control impulsive motor acts. Complex motor programs are replaced by inactive motor stereotypes. In contrast to manual kinetic apraxia, where elementary perseverations develop (for example, the patient starts drawing a circle and continues it several times), in regulatory apraxia systematic perseverations develop (for example, if the patient is asked to write his name after drawing a circle, he writes the word "circle"). That is why the main defect relates to switching between entire programs of general activity. Echopraxia (uncontrolled repeating of the movements of the examiner) occurs with massive lesions to the prefrontal cortex. This form of apraxia appears in left prefrontal cortical lesions in right-handers (Luria, 1957, 1969a,b, 2002; Korsakova & Moskovichute, 2003; Lebedinsky, 2004; Chomskaya, 2007).

To sum up, according to Luria's theory of systemic and dynamic localization of higher mental functions, such components as 1) the kinesthetic basis of movement, 2) the serial organization of movement in time (in other words, the complete kinetic basis of movement), 3) spatial synthesis, and 4) programming and voluntary regulation of movement are necessary for performing normal movements.

In his monograph *Higher cortical functions in man*, Luria thoroughly describes his methods of diagnosing different forms of apraxia (Luria, 1969b). The main diagnostic method in Luria's approach is the qualitative, syndromic analysis of HMF disorders, which is aimed at finding the mental component responsible for various neuropsychological symptoms. Different methods aimed at investigating one of the components mentioned above were offered in the framework of syndromic analysis.

To assess the kinesthetic component of movement, Luria suggested the task of reproducing various positions of the fingers according to the example given by the examiner. To identify the disturbance it is necessary to shield the patient's hand from his view in order to reduce visual control of movement. In the case of kinesthetic disorders, there is a search for the right postures and incorrect reproduction of postures.

To investigate the possibility of manual kinetic apraxia, the patient is asked to perform the "fist-edge-palm" test, when the examiner shows the patient a series of 3 hand positions, fluently changing one for the other: fist, edge and palm. This series is performed 3 times, and after that patient is asked to repeat it. In a case of kinetic disorders, the performance of the test is non-automated (elements are performed separately, with pauses between them); elements are missing or extra elements are added, the sequence is broken, and perseverations are possible.

To assess the spatial component of praxis patient is asked to complete Head's test, where patient is asked to imitate spatial oriented hand poses (Head, 1926). Patients with spatial difficulties make topological mistakes (touching the wrong part of the face, for example, cheek instead of ear); they have difficulties with spatial recoding (a long latent period of analyzing the spatial relations in the

demonstrated postures); they attempt to perform the movement with the wrong hand and then correct their mistake; there is a search for the localization of a touch (for example, left ear instead of right ear), and mirror mistakes are often make (symmetric repeating of postures after the examiner). Spatial praxis tasks are also used, including constructing whole figures from separated parts (for example, Koos cubes) and coping with complex figures.

Various tests called "reaction of choice" are used to investigate the regulatory component of praxis. In the process of conducting these tests, stable motor stereotypes are first formed and then discarded. For example,the patient is asked to react by raising the right hand to one knock and the left hand to 2 knocks. In the beginning, the signals are given in a simple sequence (A-B-A-B-A-B) to form a stereotype. Then the examiner breaks the stereotype and begins giving signals in a chaotic order. Regulatory apraxia usually appears as inertia, with impulsive mistakes and echopraxia in severe cases.

Until recently, the methods described above were widely used in Russia for the diagnosis of voluntary movement disorders in patients with focal brain lesions (Shklovsky & Vizel, 2000; Vizel, 2009; Grigoryeva, Kovyazina & Tkhostov, 2012). Each method is multifunctional; in other words, it is possible to test several components of movement with one method. For example, during Head's test we can observe regulatory and spatial mistakes, during the manual finger posture test kinesthetic and spatial mistakes can be observed, and so on. These methods provide a qualitative analysis of disorder: it is possible to ascertain which component of praxis suffers in each particular case, and which type of apraxia develops accordingly. These methods also have a number of significant advantages: the tests are easy to use, have a short duration, and can be conducted without special tools.

At the same time, however, it is important to mention that from the modern point of view, the methods developed by Luria have a number of limitations. First of all, they deal mostly with movements classified as "meaningless" actions without objects (De Renzi, 1985; Goldenberg & Hagmann, 1997; Bartolo et al., 2001; Sunderland, 2007). It is true that the various finger and manual poses performed by the patient do not have any specific meaning and cannot be found in everyday life. Besides, apraxia diagnosis in Luria's framework is conducted in terms of immediate imitation (for example, finger posture) and postponed imitation (for example, "fist-edge-palm"). It is important to mention that research on imitation assumes only the use of the visual modality and no others.

APRAXIA IN COGNITIVE FRAMEWORK

H. Liepmann, the founder of apraxia theory, was one of the first investigators to pay special attention to disorders of meaningful transitive actions (actions with objects) in patients with brain lesions (Pearce, 2009). At the very beginning of apraxia research in 1900, Liepmann described the case of an imperial councilor, known as the *Regierungsrat*, a patient who had suffered from a large brain lesion. The autokinesis dysfunction manifested itself as, for example, an inability to but-

ton up the shirt (without any significant signs of paresis). When his fingers were put on the button, he could perform the desired action, but then he could not perform it with the next button on his own initiative. The distinctive feature of this patient was that, on the one hand, spontaneous movements were relatively preserved (such as the right use of a spoon), but on the other hand the performance of tasks with verbal instructions, including using objects or performing actions with imaginary objects, was impeded or impossible. It is important to recall that the patient had no speech and vision defects, paralysis, or paresis.

Following the framework established by Liepmann, modern classifications involve three main types of voluntary actions (see Table 1):

- transitive gestures (actions performed with an object or actions assuming the use of an object, such as hammering a nail, using a toothbrush, opening a bottle);
- intransitive gestures (in other words symbolic gestures, such as saluting, waving goodbye, pointing);
- meaningless movements, as in Head's test (De Renzi, 1985; Duffy & Duffy, 1990; Bartolo, Cubelli & Della Sala, 2008).

The motor act itself can be performed in different conditions. There are three types of transitive gestures (see Table 1):

- actual performance (when it is necessary to achieve a real result, such as hammering down the nail or combing the hair);
- demonstration of the gesture (patient the demonstrates the action with an object but without reaching a result);
- pantomime (the action is demonstrated without any objects or tools actually present; Heugten, 1998; Bartolo, Cubelli, Della Sala, 2008; Vanbellingen et al., 2011).

Table 1. Assessment of voluntary movements in patients with limb apraxia

Types of gesture	Conditions of performance					
	Real performance		Demonstration of gesture		Pantomime	
	instruction	imitation	instruction	imitation	instruction	imitation
Transitive	+	?	+	+	+	+
Intransitive	+	+				
Meaningless	+ Luria	+ Luria				

Actual performance, demonstration, and pantomime can be performed in turn according to instructions, as in the case of imitation (or copying the action performed by the examiner; see Table 1; De Renzi et al., 1968; Roy, Heath, Westwood et al., 2000; Bartolo, Cubelli & Della Sala, 2008; Dovern et al., 2012). In the first case, then, the patient has no example of the action and has to perform it on his own; in the second case, an example is given. Attention should be drawn to the fact that transitive actions in imitation have virtually not been investigated, and so this would be an interesting topic for future studies.

Such a detailed classification was developed due to the larger number of dissociations between preserved and disrupted types of gesture performed in different conditions by patients with a brain lesion. As we can see in Table 1, the methods established by Luria in most cases correspond to actual performance of meaningless movements in the case of imitation.

At present, researchers are paying the most attention to transitive actions, which take a significant place in apraxia diagnosis (see Fig. 1; De Renzi, 1985; Heilman & Rothi, 1985; De Renzi & Lucchelli, 1988; Hodges, Bozeat et al., 2000; Ochipa & Rothi, 2000; Lezak et al., 2004; Bartolo, Cubelli & Della Sala, 2008).

When examining the actual performance of transitive gestures according to instruction, all the requisite objects are given, and the patient is asked to perform various actions. Their performance (such as hammering down the nail, combing the hair, opening the door with a key, etc.) is then assessed. As stated above, the actual performance of transitive gestures in the case of imitation is not used, but it could involve the examiner performing the action and then asking the patient to do the same.

While demonstrating transitive gestures according to verbal command, the patient is given up to 20 objects (such as comb, hammer, pen, key, ring, needle

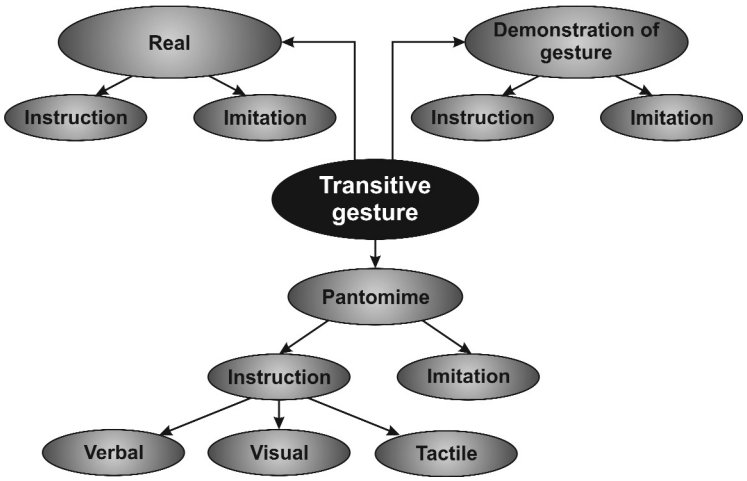

Figure 1. Methods of transitive gesture examination

etc.) and asked to show how he would use them. Unlike actual performance, this task includes only demonstration of the way of using the object, without reaching the result. For example, to demonstrate how to use a key, it is enough to take the key in the hand and present a rotational movement, while actual performance means opening a door with a key. The demonstration of imitative transitive gestures is done with objects, repeating after the instructor.

One distinctive feature of pantomime is the possibility to give instructions in different modalities: auditory, visual and tactile (see Fig. 1).The verbal instruction to pantomime includes several objects named one by one; the patient is asked to demonstrate how he would use it by hand (without actually using it). For the visual representation of objects, the patient is shown objects one by one and asked to demonstrate how he would use them, if he were holding them. While testing pantomime in tactile modality, the blindfolded patient is given an object to touch. When he recognizes the object, specialist takes it away and asks the patient to demonstrate how he would use the object. While imitating pantomime, the patient repeats pantomimes after the examiner. The dissociations recognized while performing transitive gestures in different conditions makes it possible to study more thoroughly the mechanisms of disrupted voluntary actions.

BERNSTEIN'S LEVEL THEORY OF THE MOTOR ACT

Many Soviet psychologists (especially A.N. Leontiev and N.A. Bernstein) indicated objectivity (using objects of material culture) as one of the most important characteristics of human movement (Leontiev, 1972, 1977; Bernstein, 1967, 1991,, 2008; Leontiev & Zaporozhets, 1945). They demonstrated that human movements are usually involved in meaningful activity, performed according to the current task, aimed at achieving an objective result, and mediated by tools.

The most significant contribution to the study of movement structure in Russia was made by a Soviet scientist, physiologist, psychologist, and theorist of the physiology of activity, N.A. Bernstein, who developed the level theory of motor acts (Bernstein, 1967, 1991, 2008). The model proposed by Bernstein shows a number of significant differences from A.R. Luria's model (Luria, 1957, 1969b, 2002), as well as from the cognitive model, especially the dual-route model (Rothi, Ochipa & Heiman, 1991; Cubelli et al., 2000; Chainay & Humphreys, 2002).

Bernstein argued against the mechanistic views of motor act formulated in Pavlov's classical physiology (Pavlov, 1951). Bernstein denied that motor acts are an actualized invariable stereotype, as emerges from reflex theory or cognitive models of praxis. In his studies of working movements (Bernstein, 2008) he demonstrated that even ordinary, repetitive actions (for example, walking or working operations) is not performed stereotypically, but rather is composed anew from the start on each occasion(see Figure 2). Bernstein labeled this phenomenon "repeating without repeating". He claimed that movement should be considered an active, creative act, which every time is constructed again.

This so called “live movement” (Gordeeva & Zinchenko, 1982; Zinchenko, 1996) is necessary for accommodation to the constantly changing environmental conditions (including changes in the outer world and within the body). To explain this, Bernstein proposed the principle of sensory corrections, stating that to construct effective movement in terms of changing environmental conditions, besides feedback from the result of the movement, it is necessary to have:

- ongoing feedback about current performance of the movement;
- present, ongoing correction of the movement according to this feedback (sensory correction).

The model of reflex ring (Bernstein, 2008) offered by Bernstein, instead of Pavlov’s model of the reflex arc, is based on this principle of sensory corrections. To sum up, Bernstein was one of the first scientists to call attention to the importance of current feedback (afferentation) for effective realization of movement.

Bernstein also concluded that during life the individual faces motor tasks of different classes. As the environment makes more serious demands in the course of evolution, individual encounter more complex motor tasks. To provide execution of these tasks, new types of sensory corrections and more complex types of feedback are required. New structures develop in the nervous system, superimposed over old ones, to provide new types of afferentation. To solve the motor task, a corresponding level of movement composition was formed in the process of phylogenesis, and provided with specific brain structures. Each new level forms above an older one anatomically (for example, cortical over subcortical brain structures) and functionally (newer levels provide more complex motor tasks).

Accordingly, N.A. Bernstein proposed a hierarchical structure of movement. He claimed that every movement is the result of the work of several structural and functional levels of the nervous system, each one of which makes a specific contribution to performing the motor act (Bernstein, 1967, Bernstein, 1991, Bernstein,

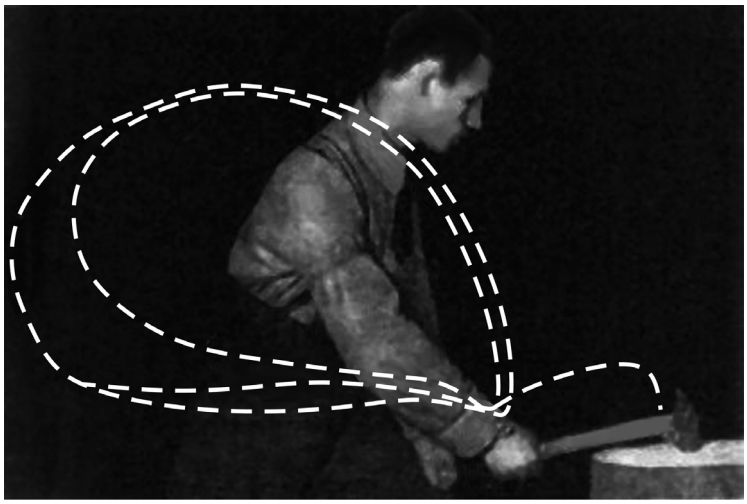

Figure 2. Working cycles (from Gastev, 1924)

2008). Depending on the meaning of the motor task , one of these levels is primary and the others are subordinated. The primary level coordinates all other levels.

The primary position of the current level is determined by the fact that each new class of motor tasks has its own type of feedback (the author calls this "primary afferentation"), which signalizes the successful performance of movement and provides corresponding sensory corrections. The primary afferentation required for the particular motor act determines the primary level of this particular movement.

There are 5 levels of movement structure suggested by Bernstein (Bernstein 1991, 2008), listed from the lowest to the highest:

A – *the level of maintaining the tonus of muscles*. This is controlled by the spinalc cord, the red nucleus group (red nucleus, substantia nigra, Darkshevich's nucleus and probably the corpus Luysi), the hypothalamus, Deiters' nucleus, the paleocerebellum, and the central part of the vegetative parasympathetic and sympathetic nervous systems. The type of motor task supplied by this level maintains muscular tonus. The primary afferentation for this level is deep proprioceptive, protopathic sensitivity. The number of movements in which this level is primary is severely limited: for example, muscular contraction when freezing.

B – *the level of synergy*. The anatomical substratum consists of the thalamus and the corpus pallidum. The motor task provided by this level is the regulation of movements "in the coordinates of one's own body", the coordination of body parts movements relative to each other without corresponding to environmental space. The primary afferentation for this level is particular joint-angular proprioceptive sensitivity and pain, temperature, vibration and tactile sensitivity. This level is primary, for example, in physical jerks.

C – *the spatial level*. Bernstein claimed that this is provided by newer nervous structures: the neocerebellar cortex, the corpus striatum, the fourth pyramidal area, and also the visual, tactile-proprioceptive, auditory and vestibular areas of cerebral cortex. The motor task of this level is performing movements in the coordinates of environmental space. The primary afferentation for this level is spacial perception ("synthetic space field"). This level is primary in throwing an object to hit the target, drawing or tracing the outline of a specific configuration.

D – the level of actions. This is provided completely by cortical structures: inferior parietal lobule, the premotor area of cerebral cortex. This level is responsible for movements with objects, which are considered not as geometric figures having a certain form, size and position in space, but as tools that are used to achieve a result in a particular way. In other words, it is critically important why and how we use the particular object. For example, this level is primary for all movements involved in the purposeful use of objects: eating with a spoon, writing with a pen, playing musical instruments, etc. "Object" is understood here not just as a physical object. It can be a scheme (for example, a plan to draw, a letter to write are considered objects). The primary afferentation is the result of the action with an object, achieved in a certain way (for example, the nail was hammered in the right way, the melody was played correctly).

E – symbolic level (Bernstein supposed that this is a group of levels). The E-level was the least studied by Bernstein, and the brain structures of this level are not sufficiently described. Bernstein mentioned only the frontal lobes in this context. The movement task of this level includes the conveyance of meaning through movement. This level is primary for all the movements of speaking and writing, when pronouncing and writing words is a means to transmit meaning. Bernstein claimed that pronouncing or writing a word according to instruction will be performed by the D – level as primary. The primary afferentation of E-level is the symbolic meaning of movement. In free dialogue, the success of speech will be judged according to whether or not the sense of the statement is conveyed, not the way the words were pronounced (that is why spelling mistakes are so common and do not influence the meaning of our speech). The E-level is specific for human activity, and for almost all human movements D and E are primary.

It is important to note that Bernstein's theory significantly differs from Luria's (Luria, 1959; Luria, 2002) as well as from modern cognitive models of praxis (Bartolo, Cubelli, Della Sala & Drei, 2003; Buxbaum, Giovannetti & Libon, 2000; Cubelli, Marchetti, Boscolo & Della Sala, 2000). Luria's theory and the cognitive models state that voluntary movement is the result of the work of several psychological components. Each component makes a specific contribution to movement, but the functional role of a component does not change when they are included in motor acts of different meaning. In this case each component is relatively independent.

In Bernstein's theory a hierarchy of levels is proposed, every newer level (starting from the lowest to the highest, from A to E) is based on lower levels and regulates their work. The work of a higher level is nothing but the work of a lower one organized (coordinated) in a new specific way according to a more complex type of afferentation. In particular, a movement with primary B-level (for example, physical jerks) includes a subordinated level A, because synergies can be implemented only through changing of muscular tonus. In this case the maintenance and changing of muscular tonus is guided by the more complex afferentation of B-level in a way that fulfils the requirements of physical exercise.

A movement with primary C-level (for example, touching a point on the wall) is also performed by changing muscular tonus (A-level) and moving body parts relative to each other (B-level), which are again controlled by more complex, spatial afferentation. Indeed, muscular tonus and body synergies are organized here to successfully solve a spatial task. In other cases, movements are organized in the same way: the higher level is a specific way of organizing the lower levels' activity, based on the afferentation of the higher level.

In contrast to Luria's theory and cognitive models, the hierarchy of levels in Bernstein's theory of motor act is considered holistic, which means that the functional role of each level can change, depending on what type of structure it belongs to (in other words, what movement task should be performed). For example, the D-level, depending on the structure of the motor act, can be:

- the primary level, in which case its afferentation will indicate the movement's success (for example, for when hammering a nail with a hammer the indicator will be the correctly hammered nail), and the activity of all other levels is regulated by the D-level.
- the subordinate level of an E-level act, in which case the E-level coordinates the work of the D-level. For example, when hammering the nail during a theatrical performance, the indicator of success will be the effectively transmitted symbolic meaning of this act, but not the accuracy of the way the nail was hammered.

The holistic structure of the motor act has one more characteristic described by Bernstein: the psychological structure of movement, which is dynamic and determined by the type of motor task. The change of meaning of a motor task leads to reorganization of the psychological structure of movement, despite the fact that visually these movements can be identical. In other words, according to Bernstein's theory, even similar movements (which look identical) can be performed under different primary levels.

Consider, for example, a movement such as those involved in playing the piano. From the point of view of modern cognitive models and Luria's systemic/dynamic localization theory, this action has its own fixed structure. According to Bernstein, this is wrong. Playing the melody, when learning to play, can be done with a primary D-level (in which case the problem of the technically correct performance of the piece of music is solved). Along with the change of motor task, the psychological structure will change as well. Performing the same piece of music at a concert has a primary E-level. The motor task changes from correct performance to transmitting feelings, the sense of the music and one's own interpretation of it. Technical performance is only a way to complete the main symbolic task. In other words, D-level is regulated by E-level.

The determination of psychological structure by the task allows us to look at motor acts in the context of the physiology of activity, which states that the motor act is defined by the meaning of performed movement, not by the environmental stimuli or its belonging to a formal type of movement: transitive, intransitive, etc.

COMPARATIVE ANALYSIS OF THE THREE THEORIES OF PRAXIS: BERNSTEIN, LURIA, AND NEUROCOGNITIVE MODELS

To sum up, Bernstein's idea of the hierarchical structure of movement has a number of significant differences from A.R. Luria's theory of voluntary actions and modern neurocognitive models of praxis (Skvortsov, 2012):

1. According to Bernstein, the structure of the motor act is determined by the type of motor task. In cognitive models (in the dual-route model particularly), the psychological structure is determined by the formal fixed classification of: 1) the movement itself (meaningless, transitive, etcc), 2) the task (actual per-

formance, pantomime, etc.), and 3) the modality of task presentation (visual, audio, tactile; Bartolo, Cubelli, Delle Salla & Drei, 2003; Rothi, Ochipa & Heiman, 1991; Chainay & Humphreys, 2002). Luria's concept is closer to cognitive models, since it states that one and the same movement is provided by the same psychological components, not depending on the type of motor task.

2. According to Bernstein, the motor act has its own holistic structure, which cannot be decomposed into independent parts: the functional meaning of each level can change according to changes in the whole structure of the movement itself, which depends on the type of motor task. Unlike Bernstein's theory, cognitive models and Luria's approach can be characterized as elementaristic. They state that the components of a movement's structure do not depend on the whole structure itself. For example, the action input lexicon will have one and the same functional meaning in all types of movements and tasks (Rothi, Ochipa & Heiman, 1991; Cubelli, Marchetti, Boscolo & Della Sala, 2000; Chainay & Humphreys, 2002).
3. Bernstein suggested that the motor act has a hierarchical structure (there are several levels in each movement, one of which is primary and regulates the work of the others). Cognitive models are usually characterized by linear structure: information processing goes consequently through a number of stages, each of which has its own cognitive mechanism. The next stage can be reached only after the previous stage is completed, and the material of the previous stage becomes the working material for the next stage. We can take the performance of spontaneous movement as an example of sequential information processing in the neurocognitive model of praxis. The work of cognitive components starts from the action semantic system, which saves and actualizes knowledge of objects and tools, and ways of using them. After this knowledge is actualized, the information goes to the next stage: the action output lexicon, which contains a number of fixed motor representations, stereotypes of common movements. The result of this stage's work is an actualized motor representation, which goes to the gestural buffer, which makes it possible to keep the representation actualized during the performance of the movement (Cubelli, Marchetti, Boscolo & DellaSala, 2000). In Luria's theory, the psychological components of praxis are disposed in a fixed structure; they work together at the same time and provide movement performance "from different sides." This structure is also not hierarchical.
4. Bernstein states that corrections based on constant feedback are necessary to provide accommodation to changing environmental conditions in real time, as well as real-time tracking of successful performance of the result of the movement. Modern cognitive models do not pay attention to real-time feedback. Both Luria and Bernstein stressed the importance of real-time feedback.
5. Developing the principle of feedback, Bernstein claims that every movement is a creative act. This means that every movement performance is constructed anew every time, unlike the idea of a fixed movement stereotype. Keeping rigid invariable stereotypes in memory is useless and maladaptive, since en-

vironmental conditions constantly change. According to Bernstein, every individual develops a universal ability to construct movements in order to solve a specific type of motor task. Cognitive models state that the motor act is provided by actualization of a fixed stereotype, kept in long-term memory (action representations in lexicons). Luria's views on this problem are similar to those of Bernstein.

CONCLUSIONS

In this article we have compared threw views on the principles and mechanisms of human voluntary movements:

1. A.R. Luria's theory of the systemic/dynamic localization of higher mental functions;
2. neurocognitive models of praxis;
3. N.A. Bernstein's concept of the level organization of movements.

We can state, based on the results of our comparative analysis, that each point of view has its own strengths and weaknesses. In Bernstein's framework, which is the least used in clinical practice, far-reaching principles are proposed for the study of motor acts. Movements should be considered as meaningful (the structure of movements is determined by the task, not only by the stimulus), holistic, hierarchical, dynamic, and creative. All these principles have been widely discussed in neuropsychological literarure (Leontiev & Zaporozhets, 1945; Zaporozhets, 1956; Vygotsky, 1982; Leontiev, 1972; Leontiev, 1977; Anokhin, 1971; Anokhin 1975; Wertheimer, 1987; Goldstein, 1939; Goldstein, 1942; Jackson, 1996; Keller, 1998; Koffka, 1998), but until recently they have rarely been used in the neuropsychology of movement, or in psychology in general. Therefore, we claim that Bernstein's theory is a fruitful and promising one for studying normal and pathological voluntary movements.

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CASE STUDY

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B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

QUANTITATIVE AND QUALITATIVE PROPRIOCEPTIVE ANALYSIS OF INDIVIDUAL DIFFERENCES: A CASE STUDY OF MULTIPLE SCLEROSIS

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SUMMARY

Background: Proprioceptive Diagnostics for individual neuropsychological differences, as a basis for temperament and character, was developed within the Mira y Lopez tradition of myokinetic psychodiagnosis, and both theoretical and experimental works in the Mira y Lopez Laboratory of the University of Barcelona using new technologies. Some quantitative parameters observed in proprioceptive fine motor behaviour and other information (qualitative) can be used during test performance. The qualitative aspects of the graphomotor performance of a participant with multiple sclerosis (MS) was distinct from that of hundreds of other individuals with no such diagnosis.

Material/ Methods: Proprioceptive Diagnosis of Temperament and Character (DP-TC) was used to observe fine motor behaviour in proprioceptive test conditions. The size and spatial deviations of a participant's performance were distinguished from models, with and without vision, whereas a qualitative analysis (global graphical behavior) provided important complementary information.

Results: In the lineograms of left hand (right hemisphere) in frontal movement in the proprioceptive sensory condition, the linearity of lines was disrupted: the subject drew non-linear forms, curves, sometimes figure-eights, and in parallels, he drew intersected lines instead.

Conclusions: If quantitative parameters are important in order to obtain the general individual neuropsychological profile, qualitative information regarding fine motor behaviour in proprioceptive sensory conditions could provide a specific pattern of importance in preliminary neurological examinations, and at lower cost. Also, this examination could help medical workers to discover the hidden patterns of any neurological pathology, and psychologists to identify any specific individual organization in proprioceptive spatial perception.

Key words: proprioceptive diagnostics, myokinetic psychodiagnosis, qualitative analysis, quantitative analysis, spatial perception

INTRODUCTION

In studies carried out to develop the Proprioceptive Diagnosis of Temperament and Character test (Spanish abbreviation: DP-TC), exploratory factor analysis (Tous, Viadé, & Muiños, 2007) and subsequent confirmatory factor analysis (Muiños, 2008) showed that the instrument had six orthogonal bipolar factors:

1. Mood (from pessimism to optimism, with depression and mania at the poles);
2. Decision-Making (from submission to dominance, with self- (directed to one self) and hetero- (directed to others) aggressiveness at the poles);
3. Attention Style: Intra-tension and extra-tension (from inward to outward, with high self-absorption and high distractibility at the poles);
4. Emotivism (from cold/distant to empathy/affiliation);
5. Irritability (from behavioral inhibition to behavioral excitability);
6. Variability (from rigidness to variability or flexibility in behavior).

These factors are different from those that can be obtained from verbal tests, since they correspond to how a person really behaves, rather than to what he/she thinks about his/her behaviour. As Kagan argues (2005), if our goal is to make reliable predictions about behaviour and to intervene effectively in it, it is more important to know how a person behaves than it is to know what that person thinks about him or herself. Moreover, as Shibutani said (cited by Miroshnikov, 1963), "the person should be determined in terms of his/her potential activity, and not what is seen by others." Real behavioral trends can be repressed. These hidden internal behavioral trends are reflected in motor function (Luria, 1932). Miroshnikov (1963), in his review of the scientific literature, described the psychological reactions that led to or were related to specific motor actions:

- *increased movement amplitude* could be a way of expressing anxiety, fear, anger, happiness, exaltation or other psychomotor excitability caused by various sources, including pharmacology;
- *deterioration of motor control* may be due to fatigue, worsening of both concentration of attention and sensorimotor coordination mechanisms;
- *decreased volume (or amplitude) of movement* was related to deterioration of motor control, with increased inhibitory impulses that led to rigidity of movements, which were observed in any asthenic states related to depression and high anxiety;
- *tempo*: conservation or stability (especially when changes occur in the environment) were related to the stability of conative force;
- *increased muscular tonus*: as a reactive protection in situations of anxiety, fear, insecurity and timidity, when the person experiences intrapsychic tension; this "demobilization," reflected in muscular hypertonia, can provoke depletion of the emotional-conative sphere, passivity and depression;
- *movements in the vertical plane*: dropping the hands and changing the posture due to gravity reflected a loss of psychomotor tonus; thus movements directed downwards denoted fatigue, unwillingness to fight or apply force, depression; on the contrary, an upright body position and the capacity to han-

dle the extremities at the same level meant activity and vitality. When the person felt psychomotor excitation (strong fear, anger and happiness), he/she had a tendency to move the hands up;

- *movements in the vertical plane:* active interest in any subject/object in the visual field was related to movement towards that subject/object; however, the highest reaction in this movement occurred when the person had strong emotions and a drive to remove the source of danger or barrier (aggressive behavior); on the other hand, a passive reaction to it, or a wish to be hidden or culpability, provoked "inward" movements (introjective aggression);
- *movements in the horizontal plane*: movements tending outwards were related to exteriorization and more social contact, while movements inwards were related with submerging into the interior world (interiorization);
- *motor disorganization*: visual or latent chaotic distribution of muscular tonus was related to behavioral disorders (mainly due to affective causes, when the perception was changed and kinesthetic control affected); here also the "psychological blockade" can be observed: paralysis of movement with high muscular tonus.

Experimental work with the use of the myokinetic method was also used to study individual differences in frustration (MacKinnon & Henle, 1948) and interhemispheral motor asymmetry in patients with schizophrenia and neurosis (Efremov, Sluchaevskii, Popov, Rozenfel'd & Dunaevskaia, 1982) and in healthy participants to study their tolerance of and adaptation to environmental changes (Berezin, 2011; Ezhov & Krivoshchekov, 2004; Draganova, 2007). This psychomotor method has been reported to be informative in behavioral changes to stress.

Thus proprioceptive methodology can be also used to measure individual profiles based on their neurological and physiological characteristics, which are reflected in psychological and behavioral types. Some quantitative measurements of special biases that appear to be a base of the psychological skeleton of individuum, also qualitative analysis can be done (any specific non-regular performances can be observed during the test performance). Some studies with Mira y Lopez's PMK were conducted to see the qualitative changes in fine motor behaviour related to intoxication (Binois & Lefetz, 1962; Alonso Fernandez, 1968).

METHODS

Specific instructions for performing the DP-TC test (Figure 1)

Lines (lineograms)

The following instructions were used in the task for all six lineogram (Fig. 2) segments, representing the three measured directions for each hand:

> Please trace over the model line from the starting point to the end; then trace back to the starting point without stopping. Repeat these movements, trying to reproduce the model line as accurately as pos-

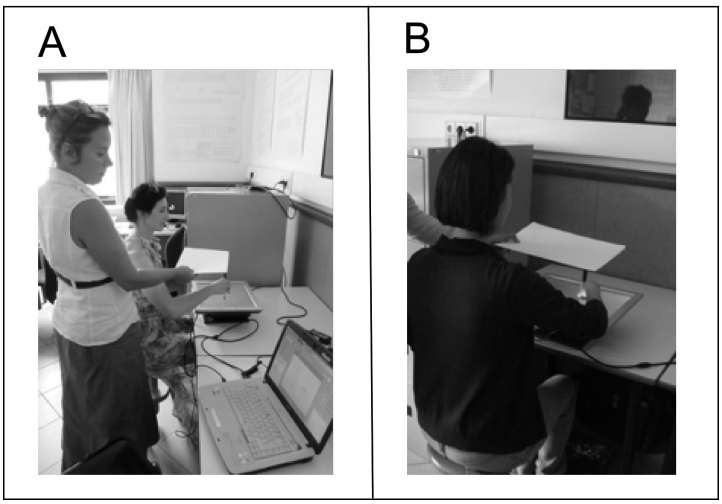

Fig. 1. The DP-TC test (right hand, transversal movement type in proprioceptive sensory condition. A: Photo by Plotka Anastacia, used by permission; B: Photo by Liudmila Liutsko

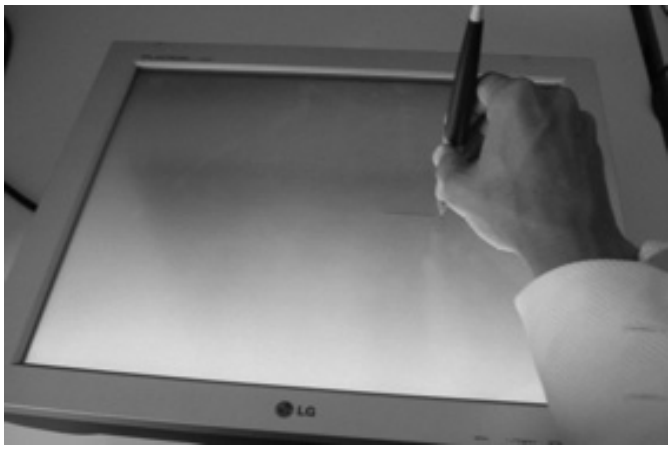

Fig. 2. Line tracking over the model (right hand, transversal movement type, visual sensory condition). Photo by Luidmila Liutsko

sible. At first you will be able to see the model line, but after some trials a piece of cardboard will be placed between you and the screen. You will not see your hand position or the line model, but you will have to continue drawing the lines as before without stopping. While performing each task, do not lift your stylus until the end of the task.

Parallels (Figure 3)

You will first have to track first lines, from the inside end to the outside, lifting the stylus at the end of each line. You will need to follow

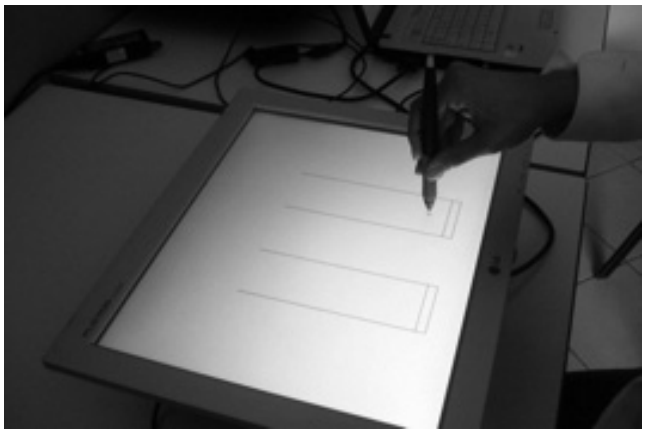

Fig. 3. Before performing the DP-TC test: stimuli – parallels; right hand, transversal movement type, visual sensory condition. Photo by Liudmila Liutsko

the drawing of parallel lines up and down (depending on whether they are ascending or descending), preserving their length and the distance between them as initially drawn (or traced). After several trials with vision, you will not be able to see the model or your active hand; however, you will have to continue until the signal or command is given to stop.

General instruction to start:

Point with the stylus to the dot you see at the beginning of the model, and when you are at the correct start position (for everyone it is the same point), the line color will be changed from red to green. At that moment, please do not move your hand or lift it; I will press the record button and give you a signal to start tracing.

RESULTS AND DISCUSSION

The two participants whose proprioceptive graphomotor performance on the DP-TC test will described below, participated as volunteers (among a total of more than 100) in research related to the topic “Proprioception and individual differences,” realized in the facilities of the Regional Epidemiological Center at Brest, Belarus. However, the performance of these two persons (Participants A and B) was qualitatively distinct from that of the other volunteers. Their stories are explained below in order to have a descriptive exploratory neuropsychological report.

Participant A (male, 31 years old)

This individual has a diagnosis of multiple sclerosis (MS) and had a fall from a high tree at age 18 (from personal interview). The DP-TC test (and the related

psychological profile) showed qualitatively only one parameter that was at the border of normality and pathology, having a standardized T-mark of 80 (where the T-range from 40 to 60 describes 67% of the population): fluctuation in behaviour, or the Variability scale and the Irritability scale. He had T=80 for these scales for both hands. The deviations for the rest of the scales were those of the majority of people, quite normal, with a slightly higher tendency to optimism in the Mood scale (see Fig. 4 for his psychological skeleton). However, the qualitative analysis of his DP-TC performance showed "rareness" in two cases:

- First, in the lineograms of frontal movement type by the left hand (right hemisphere) in the proprioceptive sensory condition (without visual control), the linearity of lines was disrupted: he drew non-linear forms, curves, sometimes similar to figure-eights.
- The second and stronger indicator was when he drew intersected lines in the part of the test where they should be parallel.

Participant B (female, 13 years old)

This was the second and the last person from this group (of 114 participants) who was observed to perform the same curved drawings instead of lines in the lineograms (Participants A and B took the DP-TC test several days apart). The most surprising thing was the remarkable similarity of drawing curves, which was repeated for the same hand and movement type (frontal movement, left hand). This girl had no observed behavior similar to the symptoms of multiple sclerosis (this disease usually develops and is diagnosed later, from 20 years old) and she kept the line parallel in another part of the test; however, she demonstrated

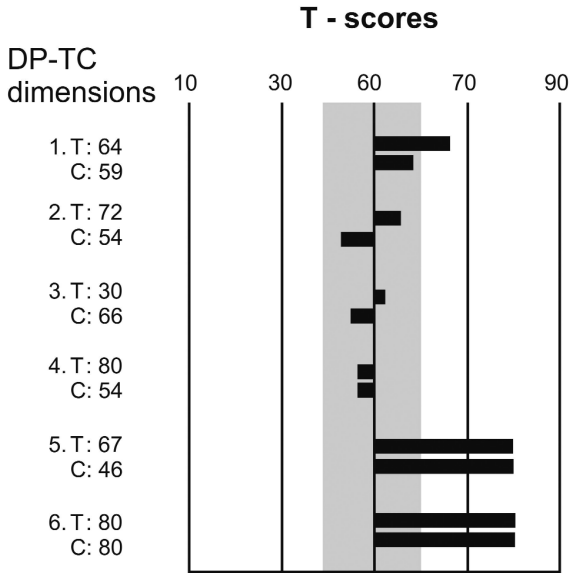

Fig. 4. The psychological skeleton with T-scores of Participant A (male, 31 years of age)

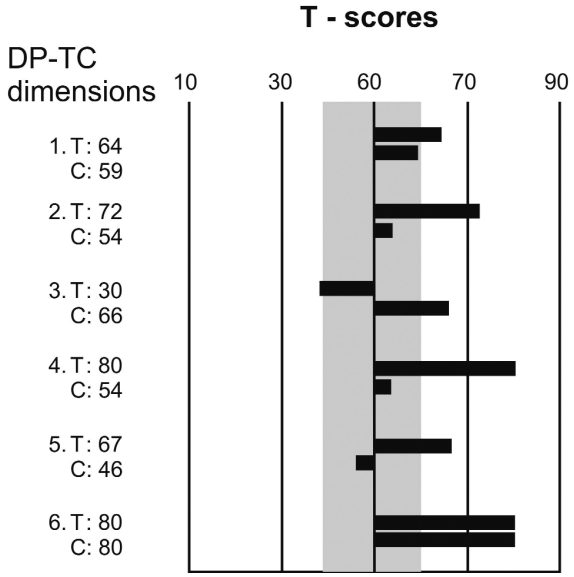

Fig. 5. The psychological skeleton with T-scores of Participant B (girl, 13 years of age)

a difficulty of upright posture throughout the whole test (15-20 minutes). As for the quantitative and psychological skeleton, she showed a similarity to Participant 1 in her temperamental tendency to optimism and „ca lear„ temperamental tendency to Irritability. As concerned the Impulsivity scales, their scores were actually identical: T=80 (borderline pathology) for both hands (see Fig. 5 for the psychological skeleton image). Another distinct indicator of her DP-TC profile, which was as high as the Impulsivity scale, was Emotivism for non-dominant hand, showing temperamental predispositions, though stabilized by her character within norms. Perhaps both a high capacity to natural Emotivism together with high Impulsivity explains why she attends art school and is an original and unusual artist (in drawing and painting). Nevertheless, one thing in drawing the line by left hand in frontal movement was very similar to the Participant A. During the interview with her mother, we asked if she remembered her daughter ever falling from a high place. The answer was affirmative: when she was 3 years old, she was pulled down by a boy as they played together on stacked construction materials; however, the height was not as great as an average tree.

CONCLUSIONS

In this particular observation of graphomotor fine behaviour in the proprioceptive test condition (when the subject does not see his/her active hand for graphic feedback, and thus cannot rectify his/her movements), we made the following observations that could be used an exploratory neurological screening:

- curves instead of lines in lineograms drawn by left (non-dominant hand) in frontal movement in participant A and B (and both had experienced falls earlier in their biographies);
- crossed lines instead of parallels could be a neurological marker of multiple sclerosis.

To sum up, qualitative analysis is important for detecting some neurological disturbances, as was shown here on the example of a multiple sclerosis case and the possible effects of falling down or other neurological damage. Further studies are required to confirm the hypotheses arising from these clinical, individual observations:

- whether intersections of lines instead of parallel occur in all (or the majority) of patients with multiple sclerosis; and
- whether non-linear representation of lineograms by the left (non-dominant) hand in the frontal movement type and proprioceptive sensory condition of the DP-TC test can help detect other neurological problems related to significant falls.

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