L. VYGOTSKY, A. LURIA AND DEVELOPMENTAL NEUROPSYCHOLOGY

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This article is devoted to Lev Vygotsky's and Alexander Luria's contribution to the theory and methods of neuropsychology, and particularly, developmental neuropsychology. The first part of the article covers the principle foundations of neuropsychology as elaborated by Vygotsky and Luria. The goal of the second part is to show what interpretation of learning disabilities can be derived from it.

Keywords: neuropsychology, cultural-historical psychology, higher mental functions.

Lev Vygotsky is a founder of cultural-historical psychology. His name is commonly associated with general and developmental psychology, educational psychology, defectology, and psychology of art. Alexander Luria is known as a founding father of neuropsychology. According to the survey of neuropsychologists, conducted by Charles Long in the 1980s, Luria was named №1 among the ten founders of neuropsychology (Puante, 1998). Why do contemporary neuropsychologists call the approach that they are developing the Vygotsky–Luria approach? There are two reasons for it. First, theoretical foundations of neuropsychology, its main principles were created by both scientists on the basis of cultural – historical concepts suggested by Vygotsky (Luria, 1967, 1980; Khomskaya, 1996; Akhutina, 2003; Achutina, 2004; Glozman, 2002). A second reason is that Vygotsky made a significant contribution to our understanding of child mental development in its norm and pathology and, consequently, a number of advancements in child neuropsychology are particularly closely connected with his ideas (Akhutina, 2010).

The following facts illustrate the joint efforts of both researchers to lay the foundation of neuropsychology. In 1925, Lev Vygotsky joined Alexander Luria in the Clinic of Nervous Diseases of Moscow University, which today is a part of the I.M. Sechenov Medical University of Moscow. There was a small laboratory headed by Luria who investigated neuroses with the help of "conjugated motor tests". Vygotsky posed another – more fundamental – problem: he wanted to discover the arguments for a new natural-scientific psychology that could explain not only elementary but also higher mental functions proper to human beings in adults, pathology, as well as in child development. He set a task to combine the paradigms of "Naturwissenschaften" and "Geisteswissenschaften". It was described in his early program (1924): "This new psychology will be a branch of the general biology and at the same time the basis of all sociological sciences. It will be the knot that ties the science of nature and the science of man together" (Vygotsky, 1997a, vol. 3, p. 61).

In November of 1930 at the "inner conference" in the same clinic Vygotsky set a goal of studying "psychological systems and their fates", i.e. their genesis, functioning and disintegration (Vygotsky, 1997a, vol. 3, pp. 91–107). In 1931 Vygotsky and Luria resumed their medical studies having been accepted at the same time to the Kharkov Medical Institute. They study together for the exams and discuss clinical cases that Vygotsky carried in Moscow (there are notes in his archive on a number of patients, some of which are presented in: Zavershneva, 2010) and Luria – in Kharkov. In his letter (June 26, 1933) from Kharkov to L.P. Linchina, his future wife, Luria wrote the following:

"I am completing my studies of aphasia patients, I keep trying to convince the old sweets that father's brother is not the same as brother's father. <…> Currently, very interesting material comes in plenty: cases of agnosia, agraphia, postnatal psychosis with aphasia <…> we are drowning in the abundance of unique cases. I am head over heels in medicine. I spend all time with Vygotsky studying pathophysiology, and, of course, thinking about you" (E.A. Luria, 1994, pp. 80-81).

Thus, it is not surprising that on November 21, 1933 in reply to Luria's question concerning the possibility of publishing a series of articles on the "investigation of higher psychological functions in their development and disintegration" Vygotsky wrote: "Finally, about the series.

If they are going to actually publish it and publish *regularly* (from issue to issue without fail), *it is necessary to take it with all responsibility*. I have [the articles] 1) The classification of aphasia; 2) Birenbaum and Vygotsky. Aphasia and dementia; 3) Birenbaum and Zeigarnik. Agnosia; 4) Vygotsky – written speech in cases of brain lesions; 5) Vygotsky – grammar *disorders* – 'ohne Zahl' [here: without number, numberless] as our patient answers the question 'How many fingers are there on one hand?' – I will submit one article by mid-December, and we will prepare 3-4 articles to keep in reserve" (Vygotsky, 2004).

Vygotsky never wrote the articles he planned, items 2 and 3 mentioned in this letter were partially completed together with G.V.Birenbaum and B.V. Zeigarnik – the proponents of Vygotsky's ideas and former students of Kurt Lewin (Samukhin, Birenbaum, Vygotsky, 1934; Zeigarnik and Birenbaum, 1935). Nevertheless, in many of Vygotsky's writings and lectures delivered in 1932-1934, especially in those from 1934, he outlined the ideas that would form a foundation for the science of neuropsychology (see for example, Vygotsky, 1995; 1997a, vol. 3, pp. 139-144, also 1998, vol. 5, pp. 128-136, 284-302). These ideas were then incorporated by A.R. Luria into the integral theory and practice of neuropsychology.

The science of neuropsychology established by Vygotsky–Luria studies the functional structure and brain organization of higher mental functions (HMF). The basic concept of neuropsychology – *higher mental functions* (= *higher psychological functions*) was developed by Vygotsky. Luria proposed two mutually additive definitions of this concept: "the higher human mental functions are complex self-regulated processes, social in origin, mediated in structure and conscious and voluntary in their mode of function" (Luria, 1980, p. 30); they "have a social genesis, a systemic structure, a dynamic development" (Luria, 1967, p. 55). The basis for distinguishing between higher and lower mental functions was revised by Vygotsky (see his notes to himself published in: Zavershneva, 2010). The reason for the revision was his transition to the systemic understanding of HMF: "Higher mental functions are not built up as a second story over elementary processes, but come as new psychological systems that include a complex merging of elementary functions that will be included in the new system, and themselves begin to act according to the new laws" (Vygotsky, 1999, vol. 6, p. 43).

Thus, the main principles of the Vygotsky–Luria neuropsychology are:

1) Social genesis of higher mental functions (HMF),

2) Systemic structure of HMF,

3) Dynamic organization and localization of HMF.

The principle of social genesis of HMF is but well-known: "every function in child's cultural development appears on the stage twice, in two planes, first – social, then – psychological; first between people as an intermental category, then within a child as an intramental category" (Vygotsky, 1997, vol. 4, p. 106). Transition from joint social functioning to individual's mental function, i.e. the process of internalization is, at the same time, according to Vygotsky, a transition from external to internal: "Every higher mental function was inevitably external because it was social before it became an internal, strictly mental function" (Vygotsky, 1997, vol. 4, p. 105).

Vygotsky describes the stages of internalization using the example of voluntary actions: "First, an inter-psychological stage – I order, you execute. Then an extra-psychological stage – I begin to speak to myself. Then an intra-psychological stage – two points of the brain that are excited from the outside (that are externally stimulated. – *T.A.*) develop a tendency to work as a unified system and eventually form an intracortical point" (1997a, vol. 3, p. 106). The stages of transition from external actions to speech and finally internal action, identified by Vygotsky, are very similar to the stages of voluntary action development described by P.Ya. Galperin (Galperin, 1969). These stages form the main path of developing or remedial interventions. We follow Vygotsky's idea that "objectification of a disturbed function, i.e. taking it outside and changing it into an external activity, is one of the basic ways to compensate for the deficiencies" (Vygotsky, 1997a, vol. 3, p. 143). This theoretical platform supplied the basis for creating remedial methods presented in our publications (Pylaeva, Akhutina: "School of attention", 1997, 4th ed. 2008; "School of Multiplication", 2007; "Learning to see and name", 2008 and other).

We should mention that Vygotsky's ideas on sociogenesis of HMF, diagnosis of the zone of proximal development and learning are more familiar to the Western scientific community than his understanding of the principles of systemic and dynamic organization of functions. They

are being used in both developmental education and rehabilitation and correction (prevention) of learning difficulties (Cole, 1985, 1996; Kozulin et al., 2003; Daniels, Cole, & Wertsch, 2007; Braga et al., 2005; Ylvisaker & Feeney, 2008; Bodrova & Leong, 2007).

The principle of systemic structure of HMF was postulated by Vygotsky but further developed by A.R. Luria. In his main publication "Higher cortical functions in man" Luria wrote: "We are indebted to Vygotsky for his detailed substantiation of the thesis that higher mental functions may exist only as a result of interaction between the highly differentiated brain structures and that each of these structures makes its own specific contribution to the dynamic whole and plays its specific part in the functional system" (Luria, 1980, p. 34). Here is what Vygotsky wrote on the subject in his last work: "It [research] demonstrates… that no specific function is ever connected with the activity of one single brain center. It is always the product of the integral activity of strictly differentiated, hierarchically interconnected centers" (1997a, vol. 3, p. 140).

The understanding of systemic structure of HMF allowed to determine their localization in brain and opened the door to the analysis of their components. This analysis was brilliantly completed by A.R. Luria. In "Essays on the Psychophysiology of Writing" (1950) A.R. Luria pioneered the task of describing the *structure of a complex functional system of writing* in norm, using a neuropsychological methodology.

Advancements in clinical neuropsychology including the analysis of the components of HMF would have been impossible without the new diagnostic approach suggested by Vygotsky and further developed by Luria. Considering the systemic character of HMF, Vygotsky identified the primary impaired component (primary defect), the secondary systemic consequences of the primary defect, and tertiary compensatory reorganizations as parts of the brain lesion syndrome in adult patients (or of abnormal development in children). The same approach was used by the authors to address learning difficulties. For example, in the very common disexecutive syndrome of learning disabilities the *primary defect* is the underdevelopment of programming and control functions (executive functions). The operations such as orientation within a task, planning, switching to other actions, inhibitory control are disturbed as part of this syndrome. All these symptoms are the examples of manifestation of a primary defect. The problems with all gnostic and mnestic processes that require concentration of attention, checking and reviewing of perceptual

hypothesis, active memorization, etc. constitute *secondary defects*. Furthermore, children with this syndrome can develop *compensatory reorganization*: positive adaptive and negative disadaptive. Self-commands, self-discussions of the task (i.e., a transition from the intra-psychological level of a voluntary action to the extra-psychological level) are examples of a positive reorganization. Adopting the role of a class clown (to attract attention, to withdraw from the situation of failure and to increase self-appraisal) is an example of a negative compensation.

To help children with this syndrome we use methods for developing programming and control functions: "School of attention" and "School of Multiplication" (Pylaeva & Akhutina, 1997/2008; 2007) mentioned above. Very similar methods also implementing Vygotsky's and Luria's ideas on development of self-regulation/executive functions in young children were suggested by E. Bodrova and D. Leong in their program "The Tools of the Mind" (Bodrova & Leong, 2007; see also Diamond et al., 2007).

The principle of dynamic organization and localization of the HMFs suggests a variability of the function's structure and its localization. Vygotsky spoke about it in his 1931 publication (vol. 5, p. 133) and in more details in his last report "The Problem of Development and Disintegration of Higher Mental Functions" (Vygotsky, 1995 – unfortunately this report was not included in his Collection of Works). Luria wrote about this principle too (Luria, 1973, 1980; Luria, Simernitskaya, & Tybulevich, 1973).

Dynamic localization occurs due to: (1) modification of the structure of functions through ontogenesis; (2) modification of the functional structure depending on the level of automatization; and, (3) the possibility of using different means to achieve the same result (for example, different strategies of information processing: holistic vs. analytic).

A good illustration of the Vygotsky–Luria principles is the data language disorders suffered by children with right and left hemispheres lesions. Infants (10-18 months) demonstrate more delayed development of both language comprehension and production in cases of right hemisphere lesions, and toddlers (19-31 months) show more delayed development of word production (than other children) and near normal comprehension in cases of left temporal lobe lesions (Thal et al., 1991; Wulfeck et al., 1991; Stiles et al., 1998). The first fact about the role of right hemisphere lesions confirms the dynamism of the organization and localization of language functions. The interpretation of the second fact

is more complicated. First of all we have to answer the question: does the given data lead to a conclusion that in two-year-old children language production is supported by brain structures of the left temporal lobe? The answer is "No, it is a secondary defect of imperfect comprehension". Almost normal results in comprehension tasks could be explained by a compensatory strategy of relying on different (not phonological but global) features of words (cf. Bates et al., 1997; Dick et al., 2005).

Modification of functional structure and localization depending on the level of automatization is described in detail by Debora Waber in the sixth chapter of her book (Waber, 2010, pp. 105-120). In Russian literature it is widely known from the works of Nikolay Bernstein (1967, 1996).

The study of the dynamic organization and localization of functions led Vygotsky to a very important conclusion (Vygotsky, 1995). He compared the consequences of lesions with the same localization in children and adults. Subordinate, underlying operations suffer more in adults, but the defect is compensated by the top levels. With children, by contrast, overlying operations that require participation of the affected component in their development are usually more affected. For example, in cases of underdevelopment of visual perception the acquisition of vocabulary and speech as a whole is affected, which, in its turn, causes problems in the development of verbal thinking and, at the same time, the delay in the development of visual thinking, i.e. partial defects of a child can cause a significant underdevelopment of a number of HMF (Vygotsky, 1995). The concept of a "developmental cascade" reflects very similar ideas in contemporary neuroscience (see e.g. Karmiloff-Smith, 2002).

However, in the course of child's development, this negative tendency is confronted by the tendency to substitute, evade, create new interfunctional connections; and "the formations which emerge much later and that are less connected with the primary derivative factor are easier to eliminate with the help of pedagogical influences" (Vygotsky, 1993, vol. 2, pp. 133-134). These tendencies (a cascading effect vs. plasticity-with greater plasticity of new formations) constantly compete in the process of child's development. The understanding of development as a continuous struggle between various tendencies is very characteristic for Vygotsky and goes along with the contemporary ideas of neurobiology. According to it, development of a function and building of functional systems is a *probabilistic self-organizing process*. Vygotsky constantly uses

the "drama" metaphor when describing it (see, for example, Vygotsky, 1993, vol. 2, pp. 241-291). Here he joins A.Gesell (1930) in thinking that "development is an uninterrupted, self-conditioned process", and that "the developmental stages in normal and abnormal children flow continuously and smoothly from one another, as the action does in a well-ordered drama" (Vygotsky, vol. 2, p. 253; see also vol.1, p. 147). He asserts: "the fundamental methodological issue in pedological research is to discover the internal logic in the drama of child development, to discover the dynamic links among its various crisis and events" (same, p. 253). Vygotsky calls his viewpoint a causal-dynamic one, in contrast to phenotypical. This approach allows to move away from the simplistic, mechanical cause-and-effect understanding of the developmental process and its deviations. It is very similar to the modern "constructivist" view of development that includes the ideas of probabilistic epigenesis, relational causality and the extreme importance of dynamic interplay (="drama") of various factors in the process of development (Gottlieb, 1992; Johnson, 1997; Karmiloff-Smith, 2002).

Genes, organism and environment (social environment in the first place) constitute the "coactive" developmental factors. Genes bring their biases into the system and thus define not a specific skill, such as reading, but "domain-relevant" functions, i.e. functions that are genetically connected, for example by belonging to the same type of input (Karmiloff-Smith, 2002). Similarly the state of certain brain structures brings its biases into a system and defines not a specific skill but "domain-relevant" functions, for example, successful development of motor or auditory functions.

Let us consider this statement in further detail. Vygotsky and Luria, along with the famous Russian physiologist N.A. Bernstein, believed that the history of behavior organization in phylogenesis is reflected in the structure of the brain: "the brain preserves in itself in a spatial form the documented temporal sequence of development of behavior" (Vygotsky, vol. 5, p. 123) and that "the development of brain proceeds according to laws of stratification and superstructure of new stories over the old" (Vygotsky, vol. 4, p. 102); new structures are built on top of the old ones while preserving the principal relatedness, the same working style, "common factor" (Luria, 1970, p. 370, see also pp. 101-103). This is why, when describing the aphasia syndromes, Luria means not only speech itself but considers related non-speech deficiencies as well. This approach is very

similar to the modern ideas of "embodied cognition": "language (as well as other abstract or higher order skills) emerges from, and is intimately linked to, the more evolutionarily entrenched sensorimotor substrates that allow us to comprehend (auditory/visual) and produce (motor) it" (Dick et al., 2005, p. 238).

Due to common morphogenesis and close functional connections certain brain structures are more closely associated with each other and the disturbance in the functioning of one will, with high probability, cause the dysfunction of the other. These "domain-relevant" connections need to be considered when analyzing symptom-complexes of developmental deviations (this is the approach that A.R. Luria called "factor analysis" or "syndrome analysis"). To better understand this approach to interpreting syndromes as "domain-relevant", let us consider one of the common types of learning difficulties: problems with reading and writing caused by "phonological deficit". This is one of the most studied syndromes in the contemporary body of research on learning disabilities. According to Shaywitz and Shaywitz (2005), "the phonological deficit is *domain-specific*; that it is independent of other non-phonological abilities. In particular, the higher order cognitive and linguistic functions… such as general intelligence and reasoning, vocabulary and syntax are generally intact" (p. 1032, emphasis added). According to our data, the phonological deficit is *domain-relevant*; it means that the syndrome usually includes also decline in short-term audio-verbal memory, poor vocabulary and secondary decline in the variability of syntactic structures; these nuclear deficiencies are accompanied by difficulties in perception of non-verbal information, specifically, rhythms which occurs with the higher than incidental probability (Akhutina, 2005; Velichenkova, Akhutina, & Inshakova, 2001). Our understanding of the syndrome is compatible with the data obtained in psycho-genetic research. Several members of a well-known today KE family diagnosed with serious speech and language impairment caused by an allelic variation in the FOXP2 gene, also experienced difficulties in perception of rhythm as well as the production of rhythmic movements of the hand (cit. Karmiloff-Smith, 2005). Difficulties in processing the non-linguistic auditory stimuli (e.g. rapidly occurring tones) were also noted in the study conducted by Tallal (1980) however, unlike the author, we do not suggest the direct strict causal relationship between the difficulties in processing the non-linguistic auditory stimuli and phonological deficit.

Let us return to the topic of "coactive" developmental factors. We have yet to consider the role of the environment in the developmental processes. Although acknowledging the important role of environment, the modern "constructivists", in our opinion, do not pay sufficient attention to the differences between biological and social environment. Vygotsky, on the contrary, drawing a close analogy between the child's development and the evolution of species, also shows the differences between child's development and development of animals and human ancestors: "The history of the child cultural development must be considered as analogous to the living process of biological evolution, to how new species of animals developed gradually, how in the process of the struggle for existence, the old species became extinct, how catastrophically adaptation of the living organisms to nature proceeded. The child development can be understood only as a living process of development, a coming into being, a struggle… At the same time the concept of conflict is introduced into the history of child development, that is, a contradiction or clash between the natural and historical, the primitive and cultural, the organic and social (Vygotsky, 1997, vol. 4, p. 221). Explaining this idea of Vygotsky, B. Meshcheryakov writes that "it is exactly in the factor of ideal form that the development of higher mental functions is sharply different from the processes of biological evolution and cultural development through history" (Meshcheryakov, 1998, p. 46).

In the course of human life a prolonged period is dedicated to the development of vitally important social patterns and learning. This period has no analogs in the animal world: the child development includes the process of internalization of social forms of behavior (thus, we are going back to the first principle). Vygostky stated: "Learning leads development", thus emphasizing the role of social environment, however, in his opinion, environment, although the main, is by no means the only character in the "developmental drama". This postulate is very important to consider when creating developing and corrective methods. Unfortunately, in many theoretical and practical studies of developmental education the presence of other "characters" of developmental drama besides the social environment is largely ignored.

Neuropsychological approach to development and correction of HMF is aimed at considering social as well as biological developmental factors.

Following Vygotsky, we consider the "developmental syndrome" (in normal or abnormal development) a biosocial unity that envelopes not only a "social situation of development", e.g. a form of adult-child interaction that is specific for every age group, but also the state of child's HMF with its weak and strong components, their systemic consequences and compensatory rearrangements (see also: Kirk, 1972; Venger, 1994). Consideration of every child's particular characteristics and organization of adequate child-adult interactions are the requirements for success in the remediation process.

Concluding the examination of the basic foundations of Vygotsky–Luria's neuropsychology and developmental neuropsychology, we will discuss two additional interconnected problems in regards to learning disabilities.

Learning difficulties (this is the term used for specific learning disorders or learning disabilities in Russian) or specific disturbance in the learning skills are defined in Russian psychology according to the ICD-10 and DSM-4. The argument that they "occur as a result of disturbances in cognitive information processing largely due to the biological dysfunction" typically is clarified in neuropsychological literature by the following argument. Learning difficulties are caused by *the partial delay* in the development of higher mental functions, e.g. more precisely, delay of their certain components.

The presence of relatively strong and weak structural functional components of mental functions can be typically seen in the population as a whole (adults as well as children) and occurs as a result of interactions between individual genetic program, individual anatomic and functional organization of brain structures, individual experience and subject's own activity. We call this phenomenon *uneven* development of HMF in children and adults (Akhutina, 1998). We identified it based on the detailed neuropsychological analysis of the state of HMF in adults and children (Akhutina, 1998; Fotekova, 2000; Melikyan, 2000; Akhutina et al., 2000). The same phenomenon is described in Schretlen et al. (2003). In the course of normal development it is possible to compensate for the weak components by implementing various strategies that utilize the strong components of HMF. If the compensation does not occur, the lack of adaptation to social norms is perceived as a deviation in developmental process and these students might be diagnosed with learning disabilities. The level of compensation may vary creating a continuum

with high functioning children with certain individual characteristics on one end of it, children who have both above and below the norm abilities in the middle and, finally, children whose strong and weak components are below the norm on the opposite end of the continuum. The idea of continuum nature of deviations in development concords well with the concept of a dimensional nature of learning disabilities and with the data of psychogenetic research (Plomin et al., 1994; Plomin & Price, 2001; DeFries & Alarcyn, 1996; Pennington, 2002).

The uneven development of higher mental functions can be clearly seen in the most widely used assessment of mental functioning by psychologists all over the world – namely, Wexler intelligence tests. It is widely known that the factor analysis of data on Wexler tests (WISK-R) has shown 3 stable factors: (1) language comprehension, (2) perceptual organization, (3) freedom from distractability (working memory) (Kaufman, Long, & O'Neal, 1986). The presence of the stable factor groups (see: Tulsky et al., 2003) shows that in general population strong and weak mental processes are not distributed in a mosaic pattern and confirm the presence of stable groups of symptoms. If we address the question what brain structures support the functions of language comprehension, perceptual organization, and working memory, the most probable answer will be that in the first case we speak about left posterior zone functions, in the second – right hemisphere functions, and in the third – left frontal functions. Thus, the revealed factor structure could be interpreted as the evidence of relative independence of left posterior zone functions, right hemisphere functions and left frontal functions. We became aware of this data only at the end of the 90-s. By that time we have already completed our initial studies in the neuropsychology of the norm that showed that normal subjects (both adults and children) can be divided into three groups depending on the presence of relative weaknesses in various components of HMF (Akhutina, 1998; Yablokova, 1998). We were very pleasantly surprised to find out that this division of normal subjects in three groups based on neuropsychological characteristics coincides with the one derived from the factor structure of Wexler's tests data. It was all the more surprising considering we used very different methods. We later found out that the forth factor – speed of information processing – was identified by combining WAIS-III and WMS-III data (Tulsky et al., 2003); it could be correlated with the state of the Lurian first unit functions.

Further studies of learning difficulties conducted with T.V.Akhutina as the advisor (Fotekova, 2004; Melikyan, 2000; Akhutina et al., 2000) showed the same. This is to be expected considering the continuum character of transitioning from norm to learning disabilities.

Thus, the use of neuropshychological methods allowed distinguishing three main types of learning disabilities:

1. Difficulties in developing academic skills in children with predominant weakness *in programming and control of actions and serial organization* of movements: due to difficulties of switching from task to task and the small volume of programming (working memory) these children experience problems with discourse (the so called compositional skills), writing, reading, problem solving and counting (Akhutina, 2004; Achutina, Obuchova, & Obuchova, 2001; Akhutina, Pylaeva, & Kamardina, in press; Polonskaya, 2002; Khotyleva et al., 2007);

2. Difficulties in developing academic skills in children with the predominant weakness of analytical (left hemispheric) strategy of *processing of auditory and kinesthetic information* (and in some cases also visual information) – in these children the primary defect is seen in phonological processing in writing and reading and in the problems of vocabulary and short-term verbal memory;

3. Difficulties in developing academic skills in children with the weakness in *holistic (right hemispheric) strategy of processing visual, visual spatial and auditory information*: children with extended vocabulary and syntax suffer difficulties in semantic-pragmatic aspect of verbal functions, difficulties in writing (surface/spatial dysgraphia), counting and math problem solving.

All three types of difficulties in developing learning skills could be combined with the problems in maintaining the optimal level of cortical tone while performing school tasks. Firstly, these can be children with ADHD as well as children with ADD suffering from hypoactivation (underaroused state), the so-called children having a sluggish cognitive tempo (see for example Morris et al, 1998; Waber, Wolff et al., 2000; Weiler et al., 2002). Secondly, it is important to have in mind that the weakness of any component in functional systems of academic skills delays the process of their automatization, that is why performing school tasks remains effortful and energy-demanded. When the function requires too high processing resources the whole functional system is overloaded and looses (or does not acquire) the necessary selectivity (see about the in-

teraction of the 1 and 3 units Luria, 1973, 1980; cf. "the automatization hypothesis in developmental context" Waber, Wolff et al., 2000; Waber, 2010, pp. 110-120).

It is worth noting that, on the one hand, all types of learning difficulties described above are widely known: the most extensively researched type is № 2, involving phonological processing; the type of learning difficulties caused by the weakness in the functioning of right hemisphere is very similar to the "syndrome of nonverbal learning disabilities" described by Byron Rourke (Rourke & Finlayson, 1978; Rourke, 1995) and to surface and constructional (spatial) dysgraphia (Chittooran & Tait, 2005); and, finally, disexecutive syndrome, although not typically mentioned in literature on learning difficulties, is often found in publications on ADHD, recently it was described by Adele Diamond as attention deficit syndrome as opposed to ADHD (Diamond, 2005).

However, on the other hand, the methods used to distinguish syndromes, the understanding of their mechanisms that is based in the neuropsychological principles of Vygotsky–Luria are different. According to their point of view, structural functional organization of any academic skill (reading, writing, math problem solving) involves widely distributed neural network, in which certain brain regions play different roles in mediating academic skills.

For example, each of the types of learning difficulties described above includes writing problems, but they are specific for each of these types. Therefore, only neuropsychological analysis that identifies primary and secondary defects and compensatory reorganization will allow to diagnosticate the syndrome and understand its mechanisms. Neuropsychological testing of child's HMF is the first step of such analysis. But because it does not permit to fully assess the possible compensatory changes in the functional systems underlying academic skills, the second step – the analysis of the manifestations of learning difficulties becomes necessary. The methods of neuropsychological analysis of students' behavior in school, analysis of mistakes students make in their school assignments (the so called methods of "tracking diagnostics", created by the authors) allow to supplement data obtained through testing and qualify learning difficulties (Akhutina, 2004; Pylaeva, 1995). The specific strategy and tactics of remedial developing education is then created based on that qualification. For more detailed discussion of different types of learning difficulties and methods of working with students from different groups,

please, refer to Akhutina & Pylaeva, 2008a; Akhutina & Pylaeva, in press, and other our publications.

In conclusion: neuropsychology of Vygotsky–Luria is a dynamic, systemic neuropsychology. The former popularity of the "static neuropsychology" that M. Johnson (1997) wrote about is decreasing. This is evident from a significant number of studies of learning difficulties – Waber, 2010; Fisher, Bernstein, Immordino – Yang, 2007; Pennington, 1999, 2006; Berninger, 2004; Berninger & Winn, 2006; Grigorenko, 2008 to name a few. The similar tendency is evident in the publications on motor control and developmental motor disorders that are highly influenced by the ideas of N.A. Bernstein (Thelen, 1995, 2000; Dewey, Tupper (Eds., 2004)). Thus, our respective positions are getting closer to each other.

However, if similar ideas can be found in the contemporary publications, why do we turn to the ideas of Vygotsky and Luria? In our opinion, this is necessary in the first place because their works contain a single integral approach to understanding the development, functioning and disintegration of mental functions in children and adults. We attempted to show that the systemic structure of HMF is necessarily derived from the principle of social origin of mental functions, while functional systems develop (and change) in the course of child development based on the interactions between biological factors and social environment, which brings us back to the principle of socio genesis of HMF. Modern ideas are, as a rule, more mosaic and often require alignment with a more holistic framework. Additionally, in Vygotsky and Luria's texts on development and disintegration of higher mental functions and normal and deviant development the deep penetration into the essence of these processes and the richness of details helps modern researchers to comprehend the newly discovered facts and create new methods to effectively help children with developmental deficiencies.

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