Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

15 Cultural-historical theory and cultural neuropsychology today

Bella Kotik-Friedgut and Alfredo Ardila

Introduction

This chapter presents a discussion about the cultural-historical approaches developed by Vygotsky and Luria in contemporary neuropsychology. Systemic-dynamic Lurian analysis of the working brain is based on the Vygotskian concept of higher mental functions. As mediators (material or symbolic) are considered to be intrinsic components of higher mental functions, the Vygotskian principle of the extra-cortical organization of psychological processes is fundamental in the development of Lurian neuropsychology and his interpretation of the brain's organization of cognition (Kotik-Friedgut and Ardila, 2004).

According to Vygotsky (1934/1978), the role of external factors (stimulus-mediators, symbols) in establishing functional connections between various brain systems is, in principle, universal. However, different mediators and means, or significantly different details within them (e.g. the specific writing system, the strategies used in spatial orientation, etc.), may and in fact do develop in different cultures. The development of new media and new virtual ways of communication also need to be considered as factors influencing brain development and functioning (Ardila, 2004). Neuropsychological diagnostic tools must be adapted to the differing cultural contexts.

The main aspects of our discussion will be focused on:

(1) cross-cultural neuropsychological research;
(2) neuropsychological aspects of illiteracy and changes in brain functions related to learning, reading, and writing;
(3) culture-related aspects of interhemispheric integration;
(4) the interaction of neurobiological and socio-cultural systems as an integral part of the discussion concerning the dilemma of biological vs. social in human psychological processes.

Neuropsychological investigation of cognitive processes, both in normal subjects and in patients with local brain lesions, has usually been performed with people who received their education mostly in Europe and North America. This specific situation resulted in a "Eurocentric worldview" that supports a universal concept of behavior and cognition. In other words, it has been implicitly assumed that all people will manifest the same behaviors when the same stimuli are presented

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

(Fletcher-Jansen, Strickland, and Reynolds, 2000; Uzzell, Pontón, and Ardila, 2007). Henrich and his colleagues (2010, p. 61) stated the problem in a strong way: "Behavioral scientists routinely publish broad claims about human psychology and behavior in the world's top journals based on samples drawn entirely from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies."

However, today neuropsychologists also work in countries with divergent cultures, frequently with immigrants of different origins, and also with illiterate people in developing countries where access to education may be limited (for a review, see Ardila, 2007). For example, as of 2000, 30 percent of the population older than fifty-five was totally illiterate in Portugal due to socioeconomic reasons. This figure was higher in small rural or fishing communities (Castro-Caldas and Reis, 2000). In some hosting countries,[1] educators have to deal with new immigrants who are illiterate and are required not only to learn the new language of the host country, but also to become literate in it. Data from cross-cultural neuropsychology become especially important for newly developing multicultural societies for decisions related to language policies in education. Donor communities make sustained efforts to empower the very poor, who are often illiterate, through access to social services and financial resources. However, some community-driven projects have not produced the expected outcomes (Abadzi, 2005). In this context, it is reasonable to suggest that for the field of applied neuropsychology, especially in education, it is particularly compelling to develop an adequate approach to the analysis of the interrelation of psychological and brain mechanisms. It is important to understand how the environment and activity within a specific environment influence the systemic-dynamic organization of higher psychological functions. It is important for the psychologist or teacher, responsible for the development and accomplishment of rehabilitation or remedial programs, to have an understanding that opens the way for a more effective use of existing techniques, together with the creative use and invention of specific new methods and techniques of learning and teaching.

Culture is a broad and overarching concept, a complex entity that includes ethnic, geographic, generational, linguistic, and social determinants, which can be dynamic due to geopolitical changes, development of new media, and globalization. "Culture" is usually defined in anthropology as the set of learned traditions and living styles, shared by the members of a society. It includes the ways of thinking, feeling, and behaving (Harris, 1983). However, culture could be defined in its simplest way as "the specific way of living of a human group" (Ardila, 2005).

The cultural-historical Vygotskian approach and Lurian systemic-dynamic neuropsychology

In this context, it is appropriate to remind the reader of some of Vygotsky's basic ideas which are important for contemporary cultural neuropsychology, in

1 For example, in Israel illiterate new immigrants from Ethiopia present a great challenge to the educational system.

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

particular the concept of the "extracortical organization of higher mental functions." The systemic-dynamic approach in analysis of brain organization of higher mental functions, developed by Alexander Luria (1966, 1973), is a logical extension and development of the ideas of Vygotsky regarding the interaction of nature and nurture, that is, the natural and cultural factors in the development of human psychological processes (Vygotsky, 1978).

According to this cultural-historical approach, higher mental functions are "social in origin and complex and hierarchical in their structure and they all are based on a complex system of methods and means" (Luria, 1973, p. 30). As mentioned above, an intrinsic factor in systemic organization of higher mental functions is the engagement of external artifacts (objects, symbols, signs), which have an independent history of development within culture.

Thus, according to the concept of "extracortical organization of complex mental functions," the role of external factors in establishing functional connections between various brain systems is, in principle, universal. However, different mediators and means, or significantly different details within them (e.g. the direction of writing and degree of letter-sound correspondence, the orientation by maps or by the behavior of seabirds, etc.) may develop and, in fact, have been developed in different cultures. Therefore, the analysis of higher mental functions must necessarily take into account these cross-cultural differences. In other words, brain-behavioral relationships are interwoven, and are dependent on environmental influences (Fletcher-Jansen, Strickland, and Reynolds, 2000; Uzzell, Pontón, and Ardila, 2007).

It is not by chance that among those who extended the inquiry into cultural aspects of brain functions were former students of Luria, although today this cultural-historical approach has attracted significant interest, and has become the focus of many younger researchers in different countries.

Goldberg, one of the students of Luria, calls Vygotsky and Luria "Russian mavericks" (Goldberg, 2005, p. 98) (that is, nonconformists, free thinkers, loners), because they were the first to formulate cultural-historical psychology and went on to study how culture in general, and language in particular, shapes individual cognition. This approach was not well accepted by the Soviet scientific establishment. Their research in Uzbekistan was mainly developmental and cross-cultural in nature;[2] only later did Luria start his groundbreaking work in neuropsychology. Goldberg also points out that Luria was ahead of his generation in his ability to think about brain and cognition with equal sophistication and his ability to integrate the two into a single narrative. The term "cognitive neuroscience," which today is a regular term, was not always thought of that way. According to Goldberg (1990), when he used the term in a group of "mainstream" neuroscientists back in the mid-1980s, he was met with disparaging looks. Based on his experience with illiterate subjects in Colombia and Mexico, Ardila, another student of Luria, coined the term "cross-cultural neuropsychology," formulating in 1995 the most

2 See Cole, 1990 for a detailed review of Luria as a cultural psychologist.

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

important directions for its further development (Ardila, 1995). In 1999, nonetheless, Kennepohl still questioned: "is a cultural neuropsychology possible?" (Kennepohl, 1999, p. 366). Nowadays, it is clearly accepted that the neuropsychologist of the new millennium has to know which concepts are universal for his/her patients, and which concepts are culture specific (Fletcher-Jansen, Strickland, and Reynolds, 2000; Uzzell, Pontón, and Ardila, 2007).

The appearance of new topics in neuroscience with corresponding new terminology is an ongoing process. Alongside neurosociology (TenHouten, 1997) and neuroanthropology (Dias, 2010), which address the relationship between mind and society, researchers are concerned about ethical problems related to issues in cross-cultural neuropsychology (Brickman, Cabo, and Manly, 2006), or the methodology of measurements when subjects of different cultures are involved (Pedraza and Mungas, 2008).

Goldberg (2001) considers "pattern recognition" as one of the neural mechanisms that allow wisdom, competence, and expertise. By "pattern recognition" he refers to the organism's ability to recognize a new object or a new problem as a member of an already familiar class of objects or problems, which is fundamental to our mental world. Certain kinds of pattern recognition devices stored in our brain capture the "wisdom" reflecting collective experience accumulated during evolution: "wisdom of the phylum" (Goldberg, 2005, p. 97). A different level of pattern recognition devices is crystallized in human culture. We benefit from knowledge stored and communicated through various cultural devices in symbolic form, and transmitted from generation to generation. Access to this knowledge automatically empowers the cognition of every individual member of human society, by making it privy to society's cumulative, collective wisdom. Natural languages are the most important meta-device from which most other cultural devices flow; mathematics, or musical notations, are examples of more specialized "languages" at our disposal. According to Goldberg (2001), the brain comes pre-wired for certain kinds of pattern recognition but not for others. This means that the brain has some capacity, in fact huge capacity, to store information about various facts and rules whose nature is not known in advance, but acquired by learning through personal experience or derived from culture. The "old" subcortical structures are preloaded with hardwired information representing the "wisdom of the phylum" and so are the cortical regions directly involved in processing sensory inputs: vision, hearing, touch. The motor cortex is, to a large degree, "pre-wired."

But the more complex cortical regions, the so-called association cortex (or, in Luria's terminology, "the tertiary zones" of the brain, which integrate information from different modality channels), have little pre-wired knowledge. Instead, their processing power is accomplished increasingly by the ability to forge their own "software," as required by their survival needs in an increasingly complex and unpredictable outside world. Pattern-recognition capacity of these most advanced areas of cortex is called "emergent," because it truly emerges in the brain, which is very complex but also very "open-minded." The evolution of the brain is dominated by one grand theme, a gradual transition from a "hardwired" to an "open-ended–open-minded" design (Goldberg, 2005).

Basic cognitive abilities and, correspondingly, their brain mechanisms, are universal and inherent for any human being, independent of language and environment (Cole, 1975), but even they need a final touch via experience (Berry, 1979). At the same time, the process of internalization in the development of higher mental functions takes place under the influence of a specific cultural context, thus shaping and moderating the process of development and the functioning of these basic cognitive abilities.

It was shown that responsiveness of newborn infants (median age nine minutes) is significantly greater to a proper face pattern, than to either of two scrambled versions of the same stimulus or to a blank. These results imply that organized visual perception is an unlearned capacity of the human organism. Moreover, the preference for the proper face stimulus by infants who had not seen a real face prior to testing suggests that an unlearned or "evolved" responsiveness to faces may be present in human neonates (Goren, Sarty, and Wu, 1975). In other words, neonates are "pre-wired" for pattern recognition related to the social environment. With experience they will learn to differentiate mother and other family members from strangers.

Even such a basic and seemingly biological ability as crying, for which a newborn is presumably "hardwired," receives a final touch in neonatal experience in a specific cultural/linguistic environment. An international group of researchers analyzed the crying patterns of thirty French and thirty German newborns (aged two to five days), with respect to their melody and intensity contours. The French group preferentially produced cries with a rising melody contour, whereas the German group preferentially produced falling contours. The data shows an influence of the surrounding speech prosody on newborns' cry melody, possibly via vocal learning based on biological predispositions (Mampe et al., 2009).

Another example of attenuation of basic abilities with experience in a certain environment can be found in cross-cultural comparison of sensitivity to visual illusions. A famous cable sent by Luria to Vygotsky – "The Uzbeks have no illusions" – reflects not only a special sense of humor of Luria, but also a real fact that in experiments with Müller-Lyer illusions, his illiterate subjects tended to see the lines as equal. People who grew up in typical Western cultural environments are much more prone to visual illusions of the Müller-Lyer type than people living in non-urban environments. Spatial abilities differ among cultures, and depend on specific ecological demands (for a comprehensive review, see Ardila, 1993a; Ardila and Keating, 2007). Recent comparisons of sensitivity to differences in length[3] among representatives of sixteen different cultural groups show that it is not merely that the strength of the illusory effect varies across populations – the effect cannot even be detected in two populations (South African miners

3 PSE (point of subjective equality) is the percentage that segment A must be longer than segment B before subjects perceive the segments as equal in length.

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

and foresters). In addition, both American undergraduates and children are at the extreme end of the distribution, showing significant differences from all other populations studied, whereas many of the other populations cannot be distinguished from one another. Children already show large population-level differences, so it is likely that there are different developmental trajectories in different societies (Henrich, Heine, and Norenzayan, 2010). Thus, once more, some basic "pre-wired" abilities are attenuated by experience in different visual environments (i.e. the Müller-Lyer illusion), which leads to sensitivity to length differences being a kind of culturally evolved byproduct (Henrich, 2008).

Spatial orientation of literate people, especially those living in modern urban space, is mediated by symbolic spatial representations –maps, charts, diagrams – based on a mathematical system of coordinates. At the same time, orientation of desert inhabitants, such as Bedouin path-finders, hunters in Amazon jungles, or Eskimo fishermen, is based on immediate perception and remembering of the position of the sun, direction of river flow, location of mountains, etc. Maybe these fundamental cultural differences, in dealing with the spatial environment, are reinforced in order to deal with the ecological demands of specific activities (hunting, fishing). Cross-cultural differences in visuospatial processes were found in several studies. Thus cross-cultural comparisons reveal, for instance, that perceptual constancy is more accurate in people with limited education from non-Western societies, than in literate and Westernized subjects (Beveridge, 1940; Myambo, 1972; Pick and Pick, 1978). Perceptual constancy may be expected to have been high (and crucial for survival) not only in prehistoric man, but also in people currently requiring a complex interpretation of the surrounding spatial environment (Ardila and Keating, 2007).

All this is possible due to plasticity of the brain, and it is reasonable to expect that most obvious cross-cultural differences in functional and/or structural brain organization of functions will be found in higher psychological functions such as speech, reading, writing, executive functions, and professional skills.

Plasticity and culture-specific skills

The term *plasticity* is broad and can mean an adjustment or adaptation of a sensory or motor system to environmental stimuli or performance requirements, or a compensation of some cerebral structures for others that are impaired due to injury or de-afferentation (Hallett, 2001).

Structural and functional imaging studies have shown that the development of new skills or the strengthening of previous ones is associated with brain reorganization. In this regard, one of the most impressive facts about influence of professional (cultural) experience on brain reorganization is the increased volume of the posterior part of the hippocampus in taxi drivers in London. The size of their hippocampus increased with the number of years spent on the job (Maguire, Gadian, and Johnsrude, 2000).

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

Draganski et al. (2006) demonstrated that acquisition of new skills may indeed change gray-matter density. Brain scans were acquired from healthy subjects before they learned juggling and three months later when they had become skilled performers. The comparison of the scans acquired before and after practice revealed an expansion in gray matter in bilateral mid-temporal areas and left posterior intra-parietal sulcus. These findings were specific to the training stimulus, as a group of controls showed no changes in gray matter over the same period. Boyke et al. (2008) observed that elderly persons (mean age sixty years) were also able to learn three-ball cascade juggling, but with less proficiency compared with twenty-year-old subjects. Similarly to the younger group, gray-matter changes in the older brain related to skill acquisition were observed in the middle temporal area of the visual cortex. In addition, elderly volunteers who learned to juggle showed transient increases in gray matter in the hippocampus on the left side and in the nucleus accumbens bilaterally.

Draganski's research group, using voxel-based morphometry, described gray-matter density changes in a group of medical students studying for their final examination. They found learning-induced structural changes in the human brain, namely a gray-matter increase in the posterior parietal cortex and in the inferior parietal cortex bilaterally. In addition, and in partial contrast to this finding, there was a continuous gray-matter increase in the posterior hippocampus throughout the three examined time points, demonstrating an increase even after the learning period (including three months after exams) (Draganski et al., 2006). The question of how stable these changes are is not clear because Woollett and collaborators (2008) revealed that medical doctors intensively acquire a large amount of knowledge over many years (as compared to IQ-matched control subjects who had no tertiary education), but it was not associated with similar hippocampal gray-matter effects as it was in taxi drivers. While the authors conclude that the main difference between doctors and taxi drivers is the spatial vs. non-spatial expertise, it seems that clearer functional and/or structural changes can be more readily detected in relation to procedural activities and procedural memory, which involves more repetitive training for professional skills.

Cerebral changes associated with musical training have during recent years represented an important research topic. It has usually been pointed out that it is largely unknown whether the unique musical abilities and structural differences that musicians' brains show are due to learning. Perhaps the differences are due to learning during critical periods of brain development and maturation, or perhaps they reflect innate abilities and capacities that might have been fostered by early exposure to music (Schlaug, 2001). Nevertheless, musicians are very convenient subjects to investigate with modern brain imaging methods in order to approach the question about the potential cerebral adaptations to unique requirements of skilled performance. Usually musicians undergo long-term motor training and continued practice of complicated bimanual motor activity, which starts when brain plasticity is still at the highest level.

Schlaug's (2001) report indicates that certain regions in the brain (corpus callosum, motor cortex, and cerebellum) may show some form of adaptation to

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

extraordinary challenges and requirements of musical performance. Experiments also reveal that unique musical abilities such as absolute pitch may be linked to one structure in the human brain (planum temporale) which is preferentially activated in musicians who have absolute pitch during tone tasks. This structure may undergo some form of functional plasticity that is possible only during a critical period of brain development, because there were significant differences in structures between subjects who started musical training before and after the age of seven.

Although some of these multiregional differences could be attributable to innate predisposition, there is a basis to believe they may represent structural adaptations in response to long-term skill acquisition, and the repetitive rehearsal of those skills. This hypothesis is supported by the strong association that was found between structural differences, musician status, and practice intensity. However, only future experiments can determine the relative contribution of predisposition and practice (Gaser and Schlaug, 2003).

Even short but intensive motor training in playing a musical instrument can produce changes in cortical representation of fingers. Even though several reports have stressed the rapid reversal of such representational changes, other studies have found persistent representational changes in response to the early acquisition of fine sensori-motor skills (which require much longer training), such as having a larger sensory finger representation in the left hand of string players (Elbert et al., 1995).

Brain organization of language and education

As a general rule, phylogenetically, more recent behavior patterns are likely to show greater variability within the species, as a result of their place in evolutionary history. Thus, it may be easier to find cultural-neurological differences in reading and writing (as opposed to speech) as a function of written language's relatively recent place in human evolution (Kennepohl, 1999). In this respect, the study of differences in functional organization of brain mechanisms of literate vs. illiterate subjects, and changes in brain organization as a consequence of learning to read, are of crucial importance (Ostrosky-Solis, 2004).

All of these processes develop new functional connections between the brain zones, connections serving these specific activities. In other words, new brain functional systems are developing via external graphic symbols. After these links are established, a person receives a powerful instrument for further development and education, opening new ways of problem solving in different domains.

Acquisition of literacy is usually associated with schooling and its profound effect is reflected in all spheres of cognitive functioning (Ardila et al., 2010). Illiterates perform worse than people who went to primary school in various neuropsychological tasks, such as ability to use ready data for deductive reasoning, short-term memory, categorization, visuospatial discrimination, numerical abilities, and abstract language (Ostrosky-Solis et al., 1998).

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

However, literate does not necessarily mean schooled, even though literacy is usually highly associated with formal schooling. Reading can be transmitted from parents or tutors to children without formal school attendance (Berry and Bennett, 1992; Scribner and Cole, 1981). Scribner and Cole (1981) attempted to separate the effects of literacy from the effects of formal schooling by studying Vai people in Liberia who were literate in the Vai script, but who had not attended school. Vai people have their own script. The script is taught at home, rather than at school, allowing the researchers to separate school-based education from literacy. Indeed, there are three educational systems in the Vai culture: (1) traditional socialization – the bush school, taught by men for boys, and by women for girls; (2) English schooling – much like American schooling; and (3) Quranic schooling – conducted in Arabic. They found that there were no general effects of literacy on a battery of cognitive tests, but performance on some tests was related to particular features of the Vai script and literacy practices. Scribner and Cole proposed that there are definite cognitive skills associated with literacy, but not necessarily with classroom learning. And these cognitive skills are dictated by each culture and situation. Berry and Bennett (1989) carried out a partial replication of this study among the Cree of Northern Ontario.

Cole and Scribner (1974) observed that when memorizing information, schooled literates and illiterates make use of their own groupings to structure their recall; for instance, high-school students rely mainly on taxonomic categories, whereas illiterate bush farmers make little use of this principle. The authors argue that cultural differences in memorizing do not consist in the presence or the absence of mnemonic techniques in general, but in the utilization of a specific technique: reorganization of the to-be-remembered material. This particular strategy for recall could be tied to school learning experiences.

Schooling is associated with visuoperceptual abilities. It has been observed that schooled European children around the age of twelve easily perceive tridimensionality in pictures whereas African children and illiterate Bantu and European laborers cannot perceive perspective in pictures (Hudson, 1962); that is, they cannot interpret three-dimensional figures which are presented on paper; this also holds generally true for illiterate people (Ardila, Rosselli, and Rosas, 1989). It is interesting to note the fact that schooling per se, independently of a specific culture – whether in India or in Europe – has a significant input, predominantly in the processes of simultaneous and successive synthesis, while in the tasks of picture remembering or in the tasks of Piagetian type, the performance of illiterate and schooled children is similar (Baral and Das, 2002).

Based on the observation that illiterate subjects significantly underscore in some neuropsychological tests, Ardila, Ostrosky, and Mendoza (2000) developed a method for learning to read, called NEUROALFA. This method is aimed at reinforcing these particular underscored abilities during the learning-to-read process. It has proved to be significantly more effective than traditional methods in teaching illiterate Mexican adults. What also seems important is that after learning to read, all subjects – both in experimental and in control groups – improved their

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

performance in neuropsychological tests, although the gain of the group that had studied using the NEUROALFA method was significantly higher in some subtests, especially in all recall tasks, verbal tasks, and even in such tasks as Orientation in Time, Digits Backward, Visual Detection, Copy of a Semi-complex Figure, Similarities, Calculation Abilities, and Sequences. It is important to emphasize that in this study the correlation between pre-test scores on a neuropsychological test and reading ability scores was generally low and non-significant. However, correlation between post-test, neuropsychological test scores and reading ability scores was significant in several subtests. This observation supports the assumption that neuropsychological test scores indeed do not exactly predict learning-to-read scores, but learning to read reinforces the abilities required to obtain a high performance in neuropsychological tests. This observation may be most important in the cognitive testing domain and in the analysis of the relationship between education and cognitive test performance.

The principle of extra-cortical organization of higher mental functions serves as a plausible framework for analysis of literacy and schooling. At the preliterate stage, the analysis of speech starts from auditory input. The visuo-auditory link is limited to the identification of the source of the utterance, while in reading this link is mediated by visual symbols. In reading, the brain integrates signals from cortical regions specialized in processing visual, phonological, and linguistic information. Learning to read is essentially setting up association between sounds, and graphic symbols-letters, synthesizing rows of these symbols into meaningful words, synthesizing groups of words into sentences, which describe things, and events of reality. Learning to write requires the use of significant graphomotor and visuospatial abilities that are not crucial for reading and are not reinforced when just learning to read. Learning the written form of language (orthography) interacts with the function of oral language (Castro-Caldas et al., 1988). Skilled reading requires proficient processing in gray-matter areas, as well as appropriate connection topology and efficient signal transmission within the white-matter pathways.

Castro-Caldas and Reis (2000) compared repetition of words and pseudowords in literate and illiterate women. Repetition of pseudowords was significantly worse in the illiterate group compared to the literate one. This difference was reflected in positron emission tomography (PET) activation images: there was a small difference between the groups while repeating real words – the left inferior parietal gyrus was more activated in the literate group and there was an important difference between the groups while repeating pseudowords. The areas that were more activated in literate subjects, as compared to illiterate ones, were the right frontal operculum/anterior insula, left anterior cingulate, left putamen/pallidum, anterior thalamus/hypothalamus, pons and medial cerebellum (vermis). The authors conclude that social and/or economic circumstances (lack of educational opportunity in this case) can be reflected in changes in the pattern of brain activation in humans, and that these changes in brain actuation, in turn, can shape behavior.

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

Reading skills can influence the spatial organization of perception. A cross-cultural comparison of the direction of picture naming in Russian and Arab children in Israel revealed no cultural differences in preschool children. In the third grade, after children are immersed in study activities within their specific cultures (i.e. the Arab children learn to read and write in Arabic and Hebrew from right to left, while Russian pupils read and write fromleft to right), differences in spatial organization of perception are revealed. All Arab children name pictures starting from the right, moving left, while all Russian children do this in the opposite direction (Badarni, 2002).

Petersson and colleagues (2007), using magnetic resonance imaging (MRI) and positron emission tomography (PET), investigated the importance of literacy for the functional hemispheric specialization. Subsequent to listening to lists of word pairs, the subjects were tested with a cued-recall test. The literate performed better than the illiterate subjects on both tasks (semantic word pairs: literate 73% correct, illiterate 53% correct; phonological word pairs: literate 60%, illiterate 25%). The results show that the illiterates are consistently more right-lateralized than their literate controls for both listening and repeating words and pseudowords and semantic or phonological word pairs. These results provide evidence suggesting that a cultural factor, literacy, influences the functional hemispheric balance in reading and verbal working-memory-related regions. In another sample, Petersson and collaborators (2007) investigated gray and white matter with voxel-based morphometry. The results showed differences between literacy groups in white-matter intensities related to the mid-body region of the corpus callosum, and the inferior parietal and parietotemporal regions (literate > illiterate). This observation suggests that the influence of literacy on brain structure related to reading and verbal working memory is affecting large-scale brain connectivity more than gray matter per se.

Using functional magnetic resonance imaging (fMRI), Dehaene and collaborators (2010) measured brain responses to spoken and written language and visual stimuli (faces, houses, tools, and checkers) in adults of variable literacy (ten were illiterate, twenty-two became literate as adults, and thirty-one were literate in childhood). As literacy enhanced the left fusiform activation evoked by writing, it induced a small competition with faces at this location, but also broadly enhanced visual responses in fusiform and occipital cortex, extending to area V1. Literacy also enhanced phonological activation to speech in the planum temporal, and afforded a top-down activation of orthography from spoken inputs. Surprisingly, most changes occurred even when literacy was acquired in adulthood, suggesting that both childhood and adult education can profoundly change cortical organization.

Ben-Shachar and her colleagues (2011) described a longitudinal fMRI study to chart individual changes in cortical sensitivity to written words as reading develops. They conducted four annual measurements of brain function and reading skills in a heterogeneous group of children, initially seven to twelve years old. These children experienced intensive word stimulation in school and in the cultural

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

environment. The results show an age-related increase in children's cortical sensitivity to word visibility in posterior left occipito-temporal sulcus (LOTS), near the anatomical location of the visual word form area. Moreover, the rate of increase in LOTS word sensitivity specifically correlates with the rate of improvement in sight word efficiency, a measure of speeded overt word reading. Other cortical regions, including V1, posterior parietal cortex, and the right homologue of LOTS, did not demonstrate such developmental changes. These results point to circuitry that extracts visual word forms quickly and efficiently and highlight the importance of developing cortical sensitivity to word visibility in reading acquisition. The growth of signals in the LOTS of individual children provides an interesting glimpse of how culturally guided education couples with experience-dependent plasticity to shape both cortical processing and reading development. It is important to remember that in adult illiterates, such sensitivity is not developed and it may take much more time and effort to develop it.

In summary, learning to read can partially change the patterns of brain activation in different conditions.

Brain dealing with more than one language

For the development of a systemic-dynamic approach to bilingualism and the interpretation of bilingual aphasia, the concept of "extracortical organization of mental functions" may be especially important (Kotik, 1984, 1992; Kotik-Friedgut, 2001, 2006). Essentially, it is the central idea for finding an explanation for one of the most intriguing and interesting features of bilingual aphasia cases – the vast variety of patterns of disorders and/or of language recovery in bilingual aphasics (Albert and Obler, 1978; Fabbro, 1999; Paradis, 1977, 1983).

Attempts at generalization and systematization of bilingual aphasia started from mono-factorial hypotheses and only later were diverse factors assumed to be involved (for review, see Kotik-Friedgut, 2001). The systemic-dynamic approach in the analysis of the brain organization of higher mental functions rejects any attempt to interpret aphasic symptoms in bilinguals as stemming from any single factor. The acceptance of a systemic-dynamic approach rules out single-factor solutions for any neuropsychological question. This approach requires that neuropsychological analysis include a demonstration of a system of interrelated factors associated with the development and disturbance of the function under consideration. This is particularly true in view of the complexities of bilingualism. According to Vygotsky's analysis (1934/1978), the course of psychological development of the first language, in early childhood, tends to be universal, while bilingualism in each individual case is a product of a combination of different factors (social, cognitive, linguistic, and biological).

In neuropsychological analysis of bilingual aphasia, all the variables and dynamics of the process of the development of bilingualism (language anamnesis) have to be taken into consideration, along with details of the neurological syndrome.

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

Special attention should be paid to the circumstances and the manner of second language acquisition. According to the principles of dynamic and extracortical organization of brain functions, the characteristics of the ways of development of a certain function (e.g. speech, reading and writing in a second language) are intrinsic to shaping the pattern of brain zones involved in the regulation of the specific functions. Stemming from such an approach, the variety of factors related to second language acquisition and use becomes critically important for neuropsychological analysis.

To some degree, the manner of language learning determines which components will be involved in the development of a new functional system. Thus, age or the level of motivation, the tools, and the information channels (primary visual or auditory) used in language learning, each of these factors has its importance in terms of shaping the functional system controlling the second language. For example, age at the start of second language learning is associated with the maturity of brain functions, and a certain level of cognitive and speech development in the first language. The formal learning of a foreign language, with an emphasis on reading and writing, involves predominantly visual perception and visual memory as basic channels of input. In contrast, during the development of the mother tongue in early childhood, the verbal visual factor becomes operative only with the start of schooling. In children blind from birth, where the visual channel is unavailable, the tactile perception becomes active in verbal processes with the acquisition of literacy. With all the above considered, it becomes logical that the most often mentioned dissociation in bilingual aphasic symptoms is in the literacy functions – reading and writing.

Vygotsky (1928/1983) stated the problem of differences in new language learning between children and adults and concluded that they use different learning strategies, because of the developmental differences in the interrelation between various cognitive functions. "In early childhood memory is the dominant function. It defines the child's thinking. Correspondingly, transitioning to abstract thinking leads to a different type of memory" (Vygotsky, 1978, p. 310). In agreement with this principle, the corresponding pattern of the brain structures involved also changes with age:

> If at an early age, damage to a specific cortical area, providing a relatively elementary basis of mental activity, unavoidably causes as a secondary "systemic" effect, the underdevelopment of a higher, superordinate structure, in mature adults . . . the opposite is true: damage to the "higher zones" leads to the disintegration of elementary functions . . . intimately dependent on higher forms of activity. (Luria, 1973, pp. 75–76)

Preschool children can learn a second language, but the ways of language learning cannot involve the study of explicit grammar rules or written forms of language. Thus, primarily auditory perception of speech in the context of communication and games will be used. In adult language learning, visual input often plays the major role. Older pupils and adults can not only use books, but also work with learning

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

aids, such as parallel reading and listening to a recorded text, or using multimedia computer programs. Correspondingly, according to the principle of extra-cortical organization of higher mental functions, a different involvement of cortical auditory and visual areas can be predicted. Therefore, it is reasonable to expect that in early bilingualism resulting from more or less parallel acquisition of both languages, the brain organization will be quite similar. We can expect differences in aphasic manifestations in early bilinguals only in the case of significant linguistic differences between the two languages, mainly with respect to written language (if the two languages of a bilingual differ in sound-symbol correspondence, the direction of reading, and so forth), while the mechanisms of auditory speech perception will be similar.

If the languages are acquired successively rather than simultaneously, it is reasonable to expect differences in their neurological organization. At the time of acquisition of each language, the brain is at different stages of maturation. Accordingly, there are developmental differences in cognitive development, as we discussed above. In new language learners the involvement of established systems of the first language is unavoidable. There is a clear transfer of skills and correlation in bilinguals, between levels of development in the two languages (Cummins, 1991).

Second language acquisition is a continuous process that can become stable or fossilized at different levels of mastery of various speech functions. In other words, one person can be fluent in speech, but not practice reading. Another can translate complex written texts perfectly but not be orally fluent.

Origins of human cognition

During the last decades, a myriad of books and journal papers has been published approaching the question of the origins of human cognition and attempting to shed light on the evolutionary development of complex psychological processes, such as language, complex perception, and executive functions (e.g. Ardila, 1993b; Cummins and Allen, 1998; Heyes and Huber, 2000; Tomasello, 2001; Travis, 2007; Walsh, 2001; Wood, 1996; Zimmer, 2005). This is, as a matter of fact, the core question in Vygotsky's and Luria's cultural-historical approach in psychology and neuropsychology.

Using contemporary neuroimaging techniques, it has been observed that verbs and nouns clearly depend on different brain area activity, and naming objects and actions is disrupted in cases of different types of brain pathology. While speaking or thinking in nouns, increased activity is observed in the temporal lobe, whereas speaking or thinking verbs activates the Broca frontal area (Raichle, 1994). By the same token, impairments in finding nouns are associated with temporal lobe pathology, whereas impairments in finding verbs are associated with left frontal damage and Broca aphasia (Ardila and Rosselli, 1994; Damasio and Tranel, 1993). Naming actions activates the left frontal operculum roughly corresponding

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

to Broca's area (Damasio et al., 2001). The neural correlates of naming concrete entities such as tools (with nouns) and naming actions (with verbs) are partially distinct: the former are linked to the left inferotemporal region, whereas the latter are linked to the left frontal opercular and left posterior middle temporal regions (Tranel et al., 2005). Broca's area may be involved in action recognition (Skipper et al., 2007). PET studies have associated the neural correlates of inner speech with activity of Broca's area (McGuire et al., 1996)

The recent discovery of mirror neurons could significantly contribute to the understanding of the brain organization of verbs. A mirror neuron is a neuron which fires both when an animal performs an action and when the animal observes the same action performed by another animal. In humans, brain activity consistent with mirror neurons has been found in the premotor cortex and the inferior parietal cortex (Rizzolatti et al., 1996; Rizzolatti and Craighero, 2004). These neurons (mirror neurons) appear to represent a system that matches observed events to similar, internally generated actions. Transcranial magnetic stimulation and positron emission tomography (PET) experiments suggest that a mirror system for gesture recognition also exists in humans and includes Broca's area (Rizzolati and Arbib, 1998). The discovery of mirror neurons in Broca's area might have important consequences for understanding brain language organization and language evolution (Arbib, 2006; Craighero et al., 2007). An obvious implication of mirror neurons is that they can participate in the internal representation of actions.

Ardila (2009, 2011) emphasized that human language has two rather different dimensions corresponding to two different language systems: lexical/semantic and grammatical. These two language systems are supported by different brain structures (temporal and frontal), and are based in different learning strategies (declarative and procedural). In cases of brain pathology, each one can be independently impaired (Wernicke aphasia and Broca aphasia). While the lexical/semantic language system may have appeared during human evolution long before contemporary man, the grammatical language system probably represents a relatively recent acquisition. Language grammar may be the departing ability for the development of metacognitive executive functions and is probably based in the ability to represent actions internally.

It was further proposed (Ardila, 2009, 2011) that historically language developed through three different stages: (1) initial communication systems using sounds and other types of information – such as gestures, etc., similar to the communication systems observed in other animals, including nonhuman primates; (2) primitive language systems using combined sounds (words) but without a grammar (language as paradigm). This type of language could be likened to the holophrasic period in language development, observed in children around one to one-and-a-half years of age; (3) communication systems using grammar (language as syntagm). During a child's language development, it is observed that the use of grammar is found after the holophrasic period. It simply means that it is a more advanced and complex stage. By the end of the second year, children begin to combine words into simple

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

sentences. Initially, sentences represent telegraphic speech (around twenty-four to thirty months of age), including two-word utterances in which connecting elements are omitted (e.g. 登 other dog, 田 child eat) (Hoff, 2003). It suggests that language initially emerges as a system of words (language as a paradigm: lexical/semantic system) and only later as a system of relations among the words (language as a syntagm: grammatical system).

Some recent studies have approached the question of the evolution of the prefrontal cortex and executive functions (Risberg, 2006; Roth and Dicke, 2005; Winterer and Goldman, 2003). Coolidge and Wynn's (2001) review of the archaeological evidence finds no convincing demonstration for executive functions among the traces left by Neanderthals. The authors conclude that the archaeological records support the hypothesis that executive function was a late and critical acquisition in human cognitive evolution.

In a very ingenious study, Stout and Chaminade (2007), using positron emission tomography (PET), recorded the brain activity from six inexperienced subjects learning to make stone tools of the kind found in the earliest archaeological records. The authors found that tool making is associated with the activation of diverse parieto-frontal perceptual-motor systems, but no activation was observed in the dorsolateral prefrontal cortex. They concluded that human capacities for sensorimotor adaptation, rather than abstract conceptualization and planning, were central factors in the initial stages of human technological evolution, such as making stone tools.

Mithen (1994, 1996) has proposed the accessibility of mental modules as the impetus for human culture at the time of the Middle/Upper Paleolithic transition, about 60,000 to about 30,000 years ago. He identified these mental modules as general intelligence, social intelligence, natural history intelligence, technical intelligence, and language. Probably, language was the most important one, increasing communication, and facilitating the transmission of knowledge, potentially resulting in an increased probability of survival and reproduction.

Which were the milestones for cultural development and how did metacognitive executive functions appear? It could be speculated that some crucial inventions fueled the development of cultural evolution (Vygotsky, 1934/1962). For instance, a kind of cognitive fluidity has been postulated as a basic requisite for executing complex human activities (Gardner, 1983). The most important candidate for this crucial invention that fueled the development of cultural evolution is language. Language allows the transmission of knowledge and facilitates survival and reproduction. Without language, children can learn from parents by imitation, but imitation is limited to elementary activities, such as making a simple stone ax. Language represents a major instrument of internal representation of the world and thinking (Vygotsky, 1934/1978). Language development obviously was a slow process taking thousands of years, but the most critical element of human language is the use of grammar, likely appearing some 10,000–100,000 years ago (Ardila, 2006). Probably, *Homo neanderthalensis* did not have a

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

grammatical language and, according to archeological evidence, did not use executive functions (Coolidge and Wynn, 2008). Language grammar likely developed from action internalization (Ardila, 2009) and is at the origin of the metacognitive executive functions.

It has also been suggested that the prefrontal lobe participates in two closely related but different executive function abilities: (1) "metacognitive executive functions": problem solving, planning, concept formation, strategy development and implementation, controlling attention, working memory, and the like – that is, executive functions as they are usually understood in contemporary neuroscience; and (2) "emotional/motivational executive functions": coordinating cognition and emotion/motivation (that is, fulfilling biological needs according to some existing conditions). The first one depends on the dorsolateral prefrontal areas, whereas the second one is associated with orbitofrontal and medial frontal areas. Current tests of executive functions basically tap the first ability (metacognitive). Solving everyday problems (functional application of executive functions), however, mostly requires the second ability (emotional/motivational); therefore, these tests have limited ecological validity. Contrary to the traditional points of view, recent evidence suggests that the human prefrontal lobe is similar to that of other primates and hominids. Other primates and hominids may possess the second (emotional executive functions) prefrontal ability, but not the first (metacognitive executive functions) one. It is argued that metacognitive executive functions are significantly dependent on culture and cultural instruments. They probably are the result of the development and evolution of some "conceptualization instruments"; language (and written language as an extension of oral language) may represent the most important one. The second executive function ability (emotional/motivational) probably is the result of a biological evolution shared by other primates (Ardila, 2008).

Conclusions

The cultural-historical approach in psychology and neuropsychology proposed by Vygotsky and Luria has continued its development in contemporary cognitive neurosciences. The introduction of new technologies, such as PET and fMRI, has allowed us to advance our understanding of the influence of experience (learning) in the brain organization of psychological processes. It has become evident that the individual cultural background (personal contextual experiences) is reflected in the idiosyncrasies of the brain organization of cognitive processes. This cultural-historical approach has also allowed the development of a progressively stronger cross-cultural neuropsychology. Today it seems self-evident that neuropsychological analysis must necessarily take into account cross-cultural similarities and differences. Cross-cultural neuropsychology has become one of the most promising research and clinical areas in the twenty-first century.

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

References

Abadzi, H. (2005). Adult illiteracy, brain architecture, and empowerment of the poor. *Adult Education and Development*, 65: 19–34

Albert, M., and Obler, L. (1978). *The bilingual brain*. New York: Academic Press

Arbib, M. A. (2006). Aphasia, apraxia and the evolution of the language-ready brain. *Aphasiology*, 20: 1125–1155

Ardila, A. (1993a). Historical evolution of spatial abilities. *Behavioral Neurology*, 6: 83–88

(1995). Directions of research in cross-cultural neuropsychology. *Journal of Clinical and Experimental Neuropsychology*, 17: 143–150

(2004). There is not any specific brain area for writing: From cave painting to computers. *International Journal of Psychology*, 39: 61–67

(2005). Cultural values underlying cognitive psychometric test performance. *Neuropsychology Review*, 15: 185–195

(2006). Origenes del lenguaje: Un analisis desde la perspectiva de las afasias. *Revista de Neurologia*, 43: 690–698

(2007). The impact of culture on neuropsychological test performance. In B. Uzzell, M. Pontón, and A. Ardila (eds.), *International handbook of cross-cultural neuropsychology* (pp. 23–45). Mahwah, NJ: Lawrence Erlbaum Associates

(2008). On the evolutionary origins of executive functions. *Brain and Cognition*, 68: 92–99

(2009). Origins of the language: Correlation between brain evolution and language development. In S. M. Platek and T. K. Shackelford (eds.), *Foundations of evolutionary cognitive neuroscience* (pp. 153–174). Cambridge University Press

(2011). There are two different language systems in the brain. *Journal of Behavioral and Brain Science*, 1: 23–36

Ardila, A. (ed). (1993b). The origins of cognitive activity. *Behavioural Neurology*, special issue, 6(2): 71–74

Ardila, A., Bertolucci, P. H., Braga, L. W., Castro-Caldas, A., Cole, M., Judd, T., Kosmidis, M. H., Matute, E., Nitrini, R., Ostrosky-Solis, F., and Rosselli, M. (2010). Cognition without reading: Neuropsychology of illiteracy. *Archives of Clinical Neuropsychology*, 25(8): 689–712

Ardila, A., and Keating, K. (2007). Cognitive abilities in different cultural contexts. In B. Uzzell, M. Pontón, and A. Ardila (eds.), *International handbook of cross-cultural neuropsychology* (pp. 109–126). Mahwah, NJ: Lawrence Erlbaum Associates

Ardila, A., Ostrosky, F., and Mendoza, V. (2000). Learning to read is much more than learning to read: A neuropsychologically-based learning to read method. *Journal of the International Neuropsychological Society*, 6: 789–801

Ardila, A., and Rosselli, M. (1994). Averbia as a selective naming disorder: A single case report. *Journal of Psycholinguist Research*, 23: 139–148

Ardila, A., Rosselli, M., and Rosas, P. (1989). Neuropsychological assessment in illiterates: Visuospatial and memory abilities. *Brain and Cognition*, 11: 147–166

Badarni, A. (2002). Neuropsychological diagnostic of memory development in young schoolchildren: Cross-cultural research. Dissertation abstract. Moscow: MSU

Baral, B. D., and Das, J. P. (2002). Intelligence: What is indigenous to India and what is shared. In R. J. Sternberg and E. Grigorenko (eds.), *International handbook on intelligence*.Cambridge University Press

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

Ben-Shachar, M., Dougherty, R. F., Deutsch, G. K., and Wandell, B. A. (2011). The development of cortical sensitivity to visual word forms. *Journal of Cognitive Neuroscience*, 23(9): 2387–2399

Berry, J. W. (1979). Culture and cognition style. In A. Marsella, R. G. Tharp, and T. J. Ciborowski (eds.), *Perspectives in cross-cultural psychology* (pp. 117–135). New York: Academic Press

Berry, J. W., and Bennett, J. (1989). Syllabic literacy and cognitive performance among the Cree. *International Journal of Psychology*, 24: 429–450

(1992). Cree conceptions of cognitive competence. *International Journal of Psychology*, 27: 73–88

Beveridge, W. M. (1940). Some racial differences in perception. *British Journal of Psychology*, 30: 57–64

Boyke, J., Driemeyer, J., Gaser, C., Büchel, C., and May, A. (2008). Training-induced brain structure changes in the elderly. *Journal of Neuroscience*, 28(28): 7031–7035

Brickman, A., Cabo, R., and Manly, J. (2006). Ethical issues in cross-cultural neuropsychology. *Applied Neuropsychology*, 13(2): 91–100

Castro-Caldas, A., Peterson, K. M., Reis, A., Stone-Elander, S., and Ingvar, M. (1988). The illiterate brain. Learning to read and write during childhood influences the functional organization of the adult brain. *Brain*, 121: 1053–1064

Castro-Caldas, A., and Reis, A. (2000). Neurobiological substrates of illiteracy. *Neuroscientist*, 6: 475

Cole, M. (1975). An ethnographic psychology of cognition. In R. Brislin, S. Bochner, and W. Lonner (eds.), *Cross-cultural perspectives of learning* (pp. 157–175). Beverly Hills, CA: Sage

(1990). Alexander Romanovich Luria: Cultural psychologist. In E. Goldberg (ed.), *Contemporary neuropsychology and the legacy of Luria*. Hillsdale, NJ: Erlbaum

Cole, M., and Scribner, S. (1974). *Culture and thought*. New York: Wiley

Coolidge, F. L., and Wynn, T. (2001). Executive functions of the frontal lobes and the evolutionary ascendancy of *Homo sapiens*. *Cambridge Archaeological Journal*, 11: 255–260

(2008). A stone-age meeting of minds: Neandertals became extinct while *Homo sapiens* prospered. A marked contrast in mental capacities may account for these different fates. *American Scientist Online*, 96: www.americanscientist.org/template/AssetDetail/assetid/56450;jsession id=aaa8s-19FU6GQB/. Accessed February 6, 2011

Craighero, L., Metta, G., Sandini, G., and Fadiga, L. (2007). The mirror-neurons system: Data and models. *Progress in Brain Research*, 164: 39–59

Cummins, D. D., and Allen, C. (1998). *The evolution of mind*. Oxford University Press

Cummins, J. (1991). Interdependence of first- and second-language proficiency in bilingual children. In E. Bialystok (ed.), *Language processing in bilingual children*. Cambridge University Press

Damasio, H., Grabowski, T. J., Tranel, D., Ponto, L. L., Hichwa, R. D., and Damasio, A. R. (2001). Neural correlates of naming actions and of naming spatial relations. *Neuroimage*, 13: 1053–1064

Damasio, A. R., and Tranel, D. (1993). Nouns and verbs are retrieved with differently distributed neural systems. *Proceedings of the National Academy of Sciences*, 90: 4957–4960

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

Dehaene, S., Pegado, F., Braga, L. W., Ventura, P., Filho, G., Jobert, A., Dehaene-Lambertz, G., Kolinsky, R., Morais, J., and Laurent Cohen, L. (2010). How learning to read changes the cortical networks for vision and language. *Science*, 330: 1359–1364

Dias, A. M. (2010). The foundations of neuroanthropology. *Frontiers in Evolutionary Neurosciences*, 2: 5

Draganski, B., Gaser, C., Kempermann, G., Kuhn, H. G., Winkler, J., Buchel, C., et al. (2006). Temporal and spatial dynamics of brain structure changes during extensive learning. *Journal of Neuroscience*, 26: 6314–6317

Elbert, T., Pantev, C., Wienbruch, C., et al. (1995). Increased cortical representation of the fingers of the left hand in string players. *Science*, 270: 305–307

Fabbro, F. (1999). *The neurolinguistics of bilingualism: An introduction*. Hove, UK: Psychology Press

Fletcher-Jansen, E., Strickland, T., and Reynolds, C. (2000). Preface. In E. Fletcher-Jansen, T. Strickland, and C. Reynolds (eds.), *Handbook of cross-cultural neuropsychology*. New York: Kluwer Academic Publishers

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books

Gaser, C., and Schlaug, G. (2003). Brain structures differ between musicians and non-musicians. *Journal of Neuroscience*, 23(27): 9240–9245

Goldberg, E. (1990). *Contemporary neuropsychology and the legacy of Luria*. Hillsdale, NJ: Lawrence Erlbaum

(2001). *The executive brain: Frontal lobes and the civilized mind*. Oxford University Press

(2005). *The wisdom paradox: How your mind can grow stronger as your brain grows older*. New York: Gotham Books

Goren, C. C., Sarty, M., and Wu, P. Y. (1975). Visual following and pattern discrimination of face-like stimuli by newborn infants. *Pediatrics*, 56(4): 544–549

Hallett, M. (2001). Plasticity of the human motor cortex and recovery from stroke. *Brain Research Review*, 36(2–3): 169–174

Harris, M. (1983). *Cultural anthropology. Culture, people, nature: An introduction to general anthropology*. New York: Harper and Row

Henrich, J. (2008). A cultural species. In M. Brown (ed.), *Explaining culture scientifically* (pp. 184–210). Washington: University of Washington Press

Henrich, J., Heine, S., and Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, 33: 61–135

Heyes, C. M., and Huber, L. (eds.) (2000). *Evolution of cognition*. Cambridge, MA: MIT Press

Hoff, E. (2003). *Language development*. Belmont, CA: Wadsworth

Hudson, W. (1962). Cultural problems in pictorial perception. *South African Journal of Sciences*, 58: 189–195

Kennepohl, S. (1999). Toward cultural neuropsychology: An alternative view and preliminary model. *Brain and Cognition*, 41: 345–362

Kotik, B. (1984). On the role of the right cerebral hemisphere in speech of bilinguals. In A. Ardila and F. Ostrosky (eds.), *The right hemisphere: Neurology and neuropsychology* (pp. 227–240). New York: Gordon and Breach

(1992). *Interhemispheric cooperation in man*. Rostov-on-Don: Rostov University Publishing House (in Russian)

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

Kotik-Friedgut, B. (2001). A systemic-dynamic Lurian approach to aphasia in bilinguals. *Communication Disorders Quarterly*, 22: 138–160

(2006). Development of the Lurian approach: A cultural neurolinguistic perspective. *Neuropsychology Review*, 16: 43–52

Kotik-Friedgut, B., and Ardila, A. (2004). Systemic-dynamic Lurian theory and contemporary cross-cultural neuropsychology. In T. Akhutina, L. Moskovich, and T. Dorothy (eds.), *A. R. Luria and contemporary psychology* (pp. 55–63). New York: Nova

Luria, A. R. (1966). *Higher cortical functions in man*. New York: Basic Books

(1973). *The working brain*. London: Penguin Books

McGuire, P. K., Silbersweig, D. A., Murray, R. M., David, A. S., Frackowiak, S. J., and Frith, C. D. (1996). Functional anatomy of inner speech and auditory verbal imagery. *Psychological Medicine*, 26: 29–38

Maguire, E. A., Gadian, D. G., Johnsrude, I. S., et al. (2000). Navigation related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Science USA*, 97: 4398–4403

Mampe, B., Friederici, A. D., Christophe, A., and Wermke, K. (2009). Newborns' cry melody is shaped by their native language. *Current Biology*, 19: 1994–1997

Mithen, S. (1994). From domain specific to generalized intelligence: A cognitive interpretation of the middle/upper palaeolithic transition. In C. Renfrew and E. B. W. Zubrow (eds.), *The ancient mind: Elements of cognitive archaeology* (pp. 29–39). Cambridge University Press

(1996). *The prehistory of the mind*. London: Thames and Hudson

Myambo, K. (1972). Shape constancy as influenced by culture, Western education, and age. *Journal of Cross-Cultural Psychology*, 3: 221–232

Ostrosky, F., Ardila, A., Rosselli, M., Lopez-Arango, G., and Uriel-Mendoza, V. (1998). Neuropsychological test performance in illiterates. *Archives of Clinical Neuropsychology*, 13: 645–660

Ostrosky-Solis, F. (2004). Can literacy change brain anatomy? *International Journal of Psychology*, 39: 1–2

Paradis, M. (1977). Bilingualism and aphasia. *Studies in Neurolinguistics*, 3: 65–121

Paradis, M. (ed.) (1983). *Readings on aphasia in bilinguals and polyglots*. Quebec: Didier

Pedraza, O., and Mungas, D. (2008). Measurement in cross-cultural neuropsychology. *Neuropsychology Review*, 18(3): 184–193

Petersson, K., Silva, C., Castro-Caldas, A., Ingvar, M., and Reis, A. (2007). Literacy: A cultural influence on functional left–right differences in the inferior parietal cortex. *European Journal of Neuroscience*, 26: 791–799

Pick, A. D., and Pick, H. L. (1978). Culture and perception. In E. C. Carterette and M. P. Friedman (eds.), *Handbook of perception. Vol. X: Perceptual ecology* (pp. 19–39). New York: Academic Press

Raichle, M. E. (1994). Visualizing the mind. *Scientific American*, 270: 58–65

Risberg, J. (2006). Evolutionary aspects of the frontal lobes. In J. Risberg and J. Grafman (eds.), *The frontal lobes. Development, function and pathology* (pp. 1–20). Cambridge University Press

Rizzolatti, G., and Arbib, M. A. (1998). Language within our grasp. *Trends in Neurosciences*, 21: 188–194

Rizzolatti, G., and Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience*, 27: 169–192

Trim: 247mm × 174mm Top: 10.544mm Gutter: 18.98mm
CUUK2622-15 CUUK2622/Yasnitsky ISBN: 978 0 521 76269 4 May 23, 2014 14:43

Rizzolatti, G., Fadiga, L., Gallese, V., and Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive Brain Research*, 3: 131–141

Roth, G., and Dicke, U. (2005). Evolution of the brain and intelligence. *Trends in Cognitive Sciences*, 9: 250–257

Schlaug, G. (2001). The brain of musicians. A model for functional and structural adaptation. *Annals of the New York Academy of Science*, 930: 281–299

Skipper, J. I., Goldin-Meadow, S., Nusbaum, H. C., and Small, L. S. (2007). Speech associated gestures, Broca's area, and the human mirror system. *Brain and Language*, 101: 260–277

Scribner, S., and Cole, M. (1981). The psychology of literacy. Boston: Harvard University Press

Stout, D., and Chaminade, T. (2007). The evolutionary neuroscience of tool making. *Neuropsychologia*, 45: 1091–1100

TenHouten, W. (1997). Neurosociology. *Journal of Social and Evolutionary Systems*, 20(1): 7–37

Tomasello, M. (2001). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press

Tranel, D., Martin, C., Damasio, H., Grabowski, T. J., and Hichwa, R. (2005). Effects of noun-verb homonymy on the neural correlates of naming concrete entities and actions. *Brain and Language*, 92: 288–299

Travis, A. (2007). *Cognitive evolution: The biological imprint of applied intelligence*. Boca Raton, FL: Universal Publishers

Uzzell, B., Pontón, M., and Ardila, A. (eds.) (2007). *International handbook of cross-cultural neuropsychology*. Mahwah, NJ: Lawrence Erlbaum Associates

Vygotsky, L. S. (1928/1983). The problem of multilinguality in childhood. *Collected writings. Vol. III* (pp. 327–329). Moscow: Pedagogica (in Russian)

(1934/1962). *Thought and language*. Cambridge, MA: MIT Press

(1934/1978). *Mind in society*. Cambridge, MA: Harvard University Press

(1978). Lecture 2. Memory and its development in childhood. *Collected works. Vol. I* (pp. 301–310). New York: Plenum Press

Walsh, D. M. (2001). *Naturalism, evolution and the mind*. Cambridge University Press

Winterer, G., and Goldman, D. (2003). Genetics of human prefrontal function. *Brain Research Reviews*, 43: 134–163

Wood, B. (1996). Human evolution. *Bioessays*, 18: 945–954

Woollett, K., Glensman, J., and Maguire, E. A. (2008). Non-spatial expertise and hippocampal grey matter volume in humans. *Hippocampus*, 18(10): 981–984

Zimmer, C. (2005). *Smithsonian intimate guide to human origins*. Smithsonian Institute: Smithsonian Books