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Commentary

A New Neuropsychology for the XXI Century

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Abstract

Regardless of the significant interest in comparing neuropsychological syndromes across cultures, little interest is observed in comparing these syndromes across time. Most of the neuropsychological syndromes were described during the late nineteenth and early twentieth century (e.g., aphasia, alexia, agraphia, acalculia, etc.). However, living conditions have so dramatically changed during the last 100 years that those classical neuropsychological syndromes have to be re-stated and reconsidered; eventually, new syndromes could be proposed. In this paper, an analysis of the impact of the new living conditions in spoken language, written language, numerical abilities, memory, spatial orientation, people recognition, and executive functions is presented. It is concluded that it is time to re-analyze and re-interpret the classical neuropsychological syndromes; and develop new assessment procedures, more in accordance with the twenty-first century living conditions.

Keywords: Cross-cultural/minority; Meta cognition

Introduction

Neuropsychology has significantly advanced in pinpointing the brain structures associated with different types of cognition (e.g., Boller & Grafman, 1988/1997; Kolb & Wishaw, 2003) and the patterns of brain activity supporting diverse intellectual tasks (e.g., Cabeza & Kingstone, 2006; www.fmriconsulting.com/brodmann/Introduction.html). A diversity of cognitive syndromes associated with the brain pathology has been described throughout neuropsychology history (aphasia, acalculia, agnosia, etc.) and today they are considered to represent a solid piece of scientific knowledge (Fig. 1).

Nonetheless, there is a major limitation in this syndrome analysis and understanding: Most of the neuropsychological syndromes were described during the late 19th and early 20th century: Aphasia (Broca, 1863; Wernicke, 1874), alexia (Dejerine, 1891, 1892), agraphia (Exner, 1881), acalculia (Henschen, 1925), apraxia (Liepmann, 1900), spatial orientation disturbances (Jackson, 1874/1932), prosopagnosia (Bodamer, 1947), visuoconstructive disturbances (Poppelreuter, 1917), and executive functioning defects (Harlow, 1848, 1868), among others. Living conditions have changed dramatically during the last 100 years. Writing no longer means not using a pencil and a paper, but using a computer word processor. Arithmetical abilities have also significantly changed; instead of writing numbers down on a paper and applying certain computational rules, we more often require the ability to use a pocket calculator. One major source of knowledge of other people's faces is through television; and a major source of knowledge of other people's voices is through the telephone. Intensive exposure to these media has been observed only over the last decades.

In this paper, I will refer to some of the "classical" neuropsychological syndromes, which were initially described when social and technological conditions were partially different from the current social and technological living conditions. In particular, I will refer to spoken language, written language, numerical abilities, memory, spatial orientation, people recognition, and executive functions. I will argue that the type of cognition originally used in writing, performing calculation tasks, and so on. One hundred years ago is not completely coincidental with the type of cognitive abilities required nowadays to perform similar

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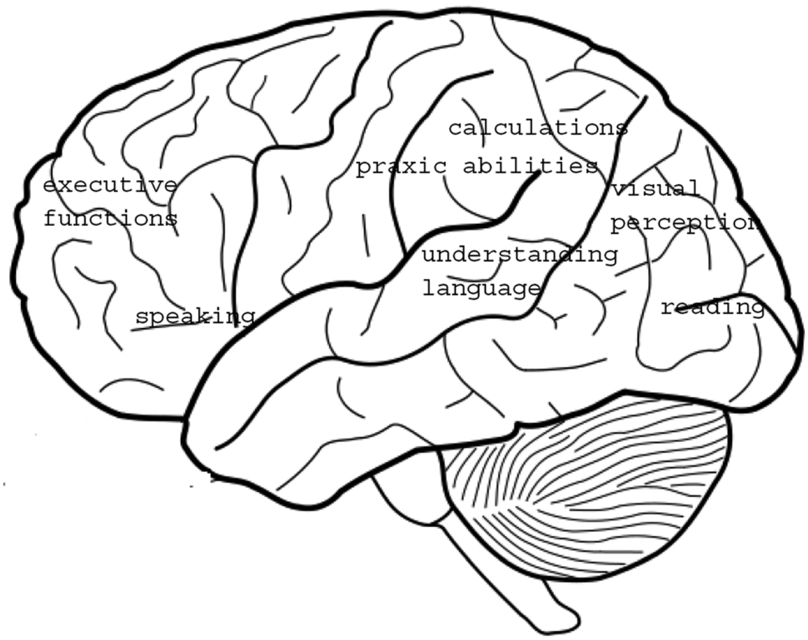

Fig. 1. Specific brain areas and systems support specific cognitive processes.

tasks. The cognitive strategies used in writing (or in calculation, etc.) one century ago and the cognitive strategies currently used in writing (or in calculation, etc.) are somehow different. Consequently, brain organization of writing ability and writing disturbances in cases of brain pathology have to be partially different. They are not completely different, just partially different.

Interesting to note, Luria (1966) introduced in neuropsychology the idea of "functional systems," taken from Anokhin (1974); functional systems are dynamic, self-organizing, and autoregulatory central-peripheral organization of which their activity is aimed at achieving adaptive results useful for the system and the organism as a whole. Luria proposed that psychological processes are indeed functional systems: That is, the same task can be done in different ways neurologically, and making changes has a direct effect in how the task is processed; simply speaking, the same task can be performed relying in different strategies and consequently using different brain circuitries. For example, writing is a functional system, even though the strategies that are used for writing may be different (handwriting, typing, etc.).

Spoken Language

Spoken language represents the most fundamental type of social interaction. The specific use of the language depends on the situational context and the conversational partner. The linguistic branch concerned with the use of language in everyday social contexts is known as "pragmatics" (Mey, 2001). But when using the language in direct face-to-face communication, not only the language itself (i.e., the linguistic information) is important for communication, but all the so-called paralinguistics elements of communication as well. Paralinguistics refers to the aspects of spoken communication that do not involve words and sentences; it includes gestures, facial expressions, body movements, and prosody (Poyatos, 1993; Traunmüller, 2005). These paralinguistic aspects of communication are used to add emphasis and/or emotion to a message.

Until recently in history, spoken language was used only in direct communication. Direct face-to-face communication nowadays is not necessarily the most frequent type of human communication. Currently, new technological developments have allowed a communication from a distance, which may include only voice (e.g., the telephone), but also a visual image (e.g., Skype; Fig. 2).

The use of the telephone has the following limitations: (a) there is no paralinguistic visual information (e.g., gestures, facial expressions, body posture, etc.); paralinguistic visual information is used to partially monitor the meaning of communication and it also used to convey emphasis/emotion (Traunmüller, 2005); (b) the telephone only uses some frequencies; higher frequencies (usually above 3,500 Hz) are filtered (www.cisco.com/en/US/prod/collateral/voicesw/ps6788/phones/ps379/ps8537/prod_white_paper0900aecd806fa57a.html); and hence, the voice lacks some prosodic characteristics, and of course, voices are harder to identify. Hence, human communication becomes restricted in some paralinguistic elements (paralinguistic visual

Fig. 2. Spoken language: In a group; face-to-face; seeing the face and listening to the voice (Skype); and only listening to the voice.

information and speech prosody). Seeing the other person (e.g., Skype) enhances the communication possibilities (e.g., allows facial gestures), but it is more limited in the amount of potential information to be transmitted than natural face-to-face communication.

A progressive increase in the use of telephones has been observed since the early 20th century; during the last couple of decades, the use of cellular phones has increased up to the point that in many countries there are more cellular phones than inhabitants (this means, many people have more than one cellular phone) (en.wikipedia.org/wiki/List_of_countries_by_number_of_mobile_phones_in_use). The use of communication systems that allow the visual image of the other person (such as Skype) is relatively new, and its use is notoriously more limited, although it can be anticipated that toward the future there will be a progressive increase in these voice/visual image communication systems.

Written Language

Writing is not anymore equivalent to handwriting, but in a significant extent, writing means to use a computer word processor. In an informal survey to 40 people with a college level of education, they reported that they write about 90% of the time using a computer, and only 10% handwriting. Obviously, this sample does not represent all of humankind, and computers are not accessible to a large percentage of the human population, but this sample seems to illustrate the way in which writing is evolving: from handwriting to typing on a computer word processor.

Regardless the enormous amount of agraphia patients reported in the neurology and neuropsychology literature (Ardila, 2012), very few cases of typewriting disturbances have been documented. For instance, Boyle and Canter (1987) described a skilled professional typist who after a left cerebrovascular accident, sustained a disturbance of typing disproportionate to her handwriting disturbance. Typing errors were predominantly of the sequencing type, with spatial errors much less frequent. Depriving the subject of visual feedback during handwriting greatly increased her error rate. The authors suggested that impaired ability to utilize somesthetic information—probably caused by the subject's parietal lobe lesion—may have been the basis of the typing disorder.

Writing using a computer keyboard obviously is not the same cognitive, motor, and spatial task as using a pencil and a paper. Although the conceptual knowledge of written language can be the same, the motor activity and the spatial abilities that are used are rather different (Fig. 3).

During handwriting, fingers are maintained in a relative steady position, and the hand is moved. In typing, the opposite pattern is used. As a matter of fact, the fingers' movements, not the hand movements, are used in typing. The right hand (usually) is not

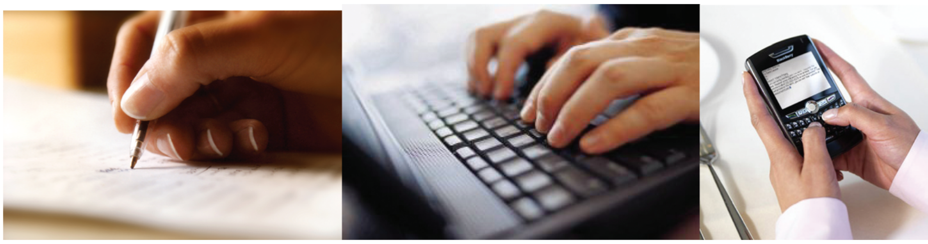

Fig. 3. Handwriting with pencil and paper, typing on a computer keyboard, and typing on a cell phone require not only different types of movements, but also different spatial skills.

slipped from left to right (and back), but the hands remain relatively stationary and only the fingers are moved. Letters are not written but selected. Both hands have to be used when typing. Because of using both hands, we have to assume that a major inter-hemispheric integration is required. It is obvious to assume that right hemisphere lesions located in frontal and parietal areas should significantly impair the ability to typewrite using the left hand.

Similarly, the use of the space is different. The computer automatically selects the spatial distribution of the words in the page, and hence, writing cannot be spatially disorganized, as it may be the case in handwriting. When typing, we are not using a space that directly is manipulated with the hands (constructional space) but only a visual space. Furthermore, typing is not a constructional task (we do not have to construct the letters), but rather a motor-spatial task.

Many people type using a spatial memory for the position of the letters in the keyboard. This type of spatial memory likely depends of right hippocampus and parietal activity (Squire, 1992). Other people have to look at the keys for selecting the letters. In such a case, literal reading is a pre-requisite for writing. Letters have to be visually recognized before they are written. In handwriting, we use a mental representation of the visual form of the letters.

When writing some special symbols (e.g., interrogation marks) and letters, relatively sophisticated motor maneuvers are required. For instance, to place the accents in languages using accent marks (e.g., French, Spanish) requires the use of special keys or sequences of movements. This is not the case in handwriting. Special symbols are written using the mental form that we have. When deciding if a letter should be lower or upper case, a lever has to be pushed.

The question is: how can typewriting be impaired in cases of brain damage? It can be assumed that different types of brain pathology may affect the ability for typing in a computer word processor.

(1) Obviously, an anterior callosal lesion would impair the ability to coordinate the movements between both hands (Bourekas *et al.*, 2012). Furthermore, the left hand would be isolated from the linguistic left hemisphere and would be unable to write. Left hand agraphia has been observed in callosal lesions (Watson & Heilman, 1983). Interestingly, attention to the hands disrupts skilled typewriting (Logan & Crump, 2009; Tapp & Logan, 2011).
(2) By the same token, it has been observed that damage in the supplementary motor area results in disturbances in the coordinated movements between both hands (Erdler *et al.*, 2000). A supplementary motor area typewriting agraphia can be anticipated. Supplementary motor area damage partially impairs handwriting: Writing is low and paragraphias are observed (Benson & Ardila, 1996).
(3) Spatial memory disturbances should result in difficulties in recalling the letter positions on the keyboard. Typing would be slow and would require a permanent search for the letters on the keyboard. This was indeed observed in the case of typewriting agraphia described by Boyle and Canter (1987).

Otsuki and colleagues (2002) reported on a 60-year-old right-handed Japanese man who showed an isolated persistent typing impairment without aphasia, agraphia, apraxia, or any other neuropsychological deficit. They proposed the term "dystypia" for this peculiar neuropsychological manifestation. The symptom was caused by an infarction in the left frontal lobe involving the foot of the second frontal convolution and the frontal operculum. The patient's typing impairment was not attributable to a disturbance of the linguistic process, since he had no aphasia or agraphia; nor was it attributable to an impairment of the motor execution process, since he had no apraxia. Thus, it was deduced that his typing impairment was based on a disturbance of the intermediate process where the linguistic phonological information is converted into the corresponding performance. The authors hypothesized that the foot of the left second frontal convolution and the operculum may play an important role in the manifestation of "dystypia."

There is no question that one of the most important uses of written language is to write letters. But the extended use of electronic mails (e-mails) has significantly changed not only the cognitive abilities required to write letters, but also the language style that is used in written communication. An additional change refers to the increased written communication among different people.

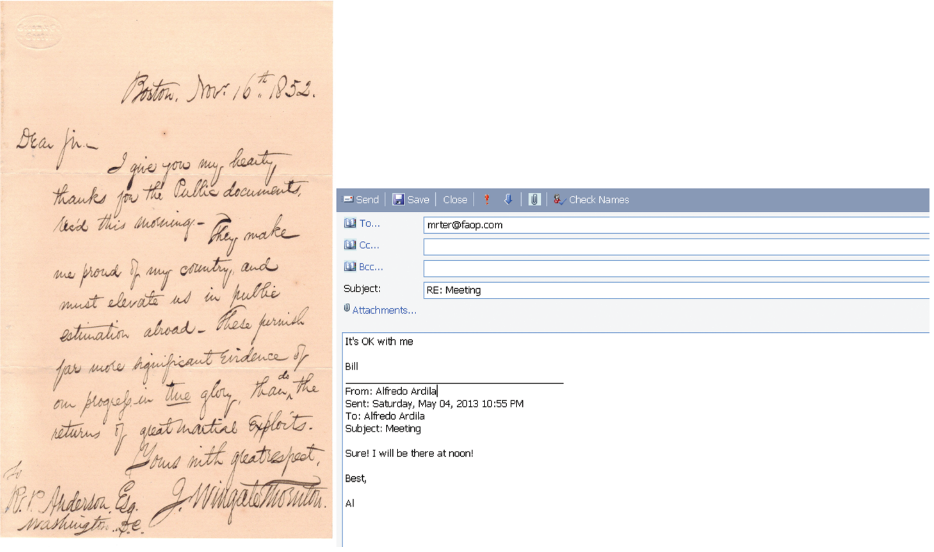

Fig. 4. A "traditional" letter and a contemporary e-mail.

Table 1. World-wide illiteracy rate during the XX century (adapted from UNESCO, 2010)

Year	Illiteracy rate (%)
1900	80
1950	45
1970	37
1980	30
1990	25
2000	20
2010	15

If writing a traditional letter can be time-consuming, writing an e-mail usually takes a few minutes. Some years ago, there was a kind of traditional formal style to write letters; currently, we may write dozens of e-mails in one day (Fig. 4). Furthermore, the writing style is different; e-mails are notoriously shorter, simpler, and more informal than traditional letters. E-mails began to be used very recently, toward the end of the 20th century, but during this last decade, their increased use has been accelerated; currently, trillions of e-mails are sent every year! (http://email.about.com/od/emailtrivia/f/emails_per_day.htm).

Reading has become a progressively more and more important activity in the contemporary world. It may be conjectured that written communication has significantly replaced oral communication. Contemporary people spend a significant amount of time every day reading.

It is not easy to calculate how many hours an average middle class person with a college level of education spends reading during his/her lifespan. However, if we suppose that this person spends only 5 h reading daily (not just reading a book or the newspaper, but exposed to written language) during 60 years, that results in 109 500 h! It simply means that we are devoting a significant percentage of our lives (and our brains!) to process written information.

Illiteracy world-wide is currently about 15% (UNESCO, 2010), but only one century ago, it was around 80% (Table 1). By the same token, the amount of books, magazines, journals, and general written information has grown in a similar way.

Numerical Abilities

Counting and in general, numerical abilities begin with the finger sequencing. During child development, different stages in the acquisition of numerical knowledge are observed (Klein & Starkey, 1987). They include global quantification, recognition of small quantities, numeration, correspondence construction, counting, and arithmetic (Antell & Keating, 1983). The initial levels of numerical knowledge are found in preschool children. The development of complex numerical concepts requires extensive school training. Complex arithmetical concepts depend upon a painstaking learning process, and they are not usually found in illiterate people. The different stages in the acquisition of numerical concepts are associated with the language, perceptual, and general cognitive development. Computational strategies (e.g., adding; if a new item is included in a collection, the collection will become larger and the next cardinal number name will be given to that collection) are found in 3–5-year-old children, initially only for small quantities. Adding and subtracting numerical quantities and the use of computational principles are observed in first–second grade children, but they only become able to manipulate the principles of multiplying and dividing after a long and painstaking training period, usually during third–fifth school grade (Antell & Keating, 1983; Klein & Starkey, 1987). Understanding that subtracting is the inverse operation of adding is usually acquired at about 5–6 years. At this age, the child begins to use three different procedures for performing additions and subtractions: (a) counting using fingers, (b) counting aloud not using fingers, and (c) memorizing additions and subtractions for small quantities (one plus one is two, two plus two is four, two minus one is one, etc.). The last strategy becomes progressively stronger with advancing age and schooling. Nonetheless, children continue using their fingers for adding and subtracting larger quantities (Levine, Jordan, & Huttenlocher, 1992).

The loss of the ability to perform calculation tasks resulting from a cerebral pathology is known as “acalculia or acquired dyscalculia” (Boller & Grafman, 1985). Acalculia can be defined as an acquired disturbance in computational ability (Loring, 1999). Several classifications have been proposed for acalculias. The most traditional classification distinguishes between a primary acalculia and a secondary acalculia (Berger, 1926). A primary acalculia refers to a fundamental defect in computational ability; secondary acalculia can result from linguistic defects (oral or written), spatial deficits, and executive function (frontal) disturbances, such as attention impairments, perseveration, and disturbances in handling complex mathematical concepts (Ardila & Rosselli, 2002).

“Anarithmetia” corresponds to primary acalculia (Hécaen, Angelerges, & Houllier, 1961). The patients with anarithmetia present a loss of numerical concepts, inability to understand quantities, defects in using syntactic rules in calculation (e.g., “to borrow”), and deficits in understanding numerical signs. However, they may be able to count aloud and to perform some other rote numerical learning (e.g., the multiplication tables). They may conserve some numerical knowledge but fail in comparing numbers (magnitude estimation) and performing arithmetical operations. In primary acalculia, the calculation defect must be found in both oral and written operations. That is, anarithmetia is a fundamental calculation defect and is not restricted to a specific type of output (oral or written). Anarithmetia could be interpreted as an acquired defect in understanding how the numerical system works (Ardila & Rosselli, 2002).

However, few contemporary people (excluding school children) use paper and pencil in arithmetical calculations (Fig. 5). Pocket calculators were introduced about 40 years ago, and they have become so extended, that even most cellular phones usually include a

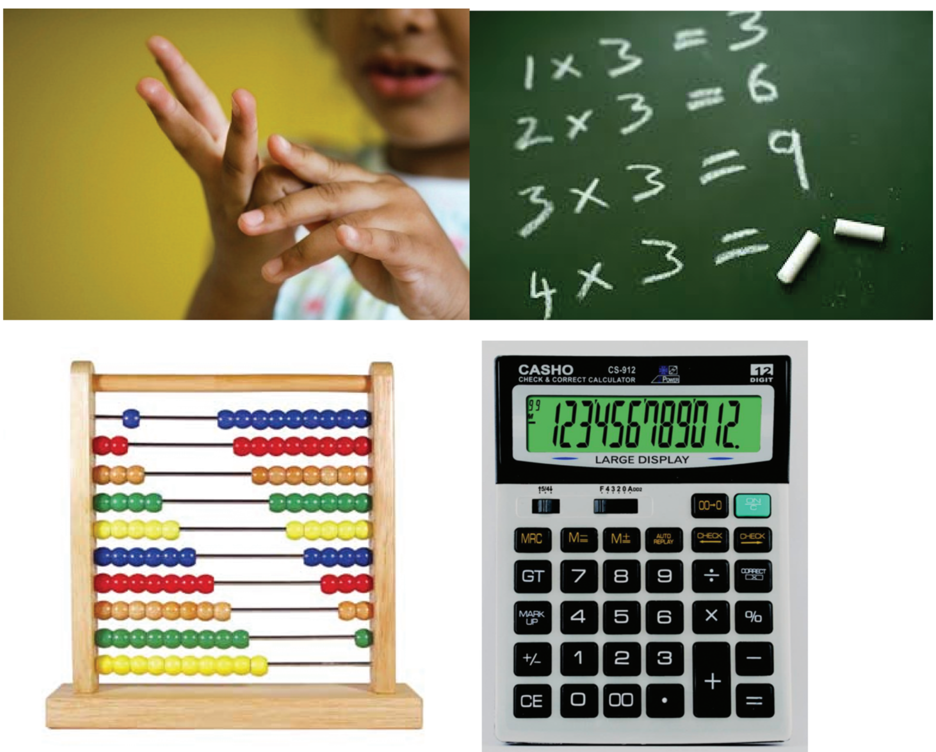

Fig. 5. Performing arithmetical operations using fingers, an external representation of written quantities (e.g., a blackboard, a paper, etc.), an abacus, and a pocket calculator.

calculator. Simply speaking, people no longer use the arithmetical knowledge in solving numerical operations; "borrowing", "carrying", and so on are principles that we do not have to take into consideration any more when using a pocket calculator.

We can assume that just some few millennia ago, acalculia and finger agnosia were the very same neuropsychological syndrome (Ardila & Rosselli, 2002). We can further conjecture that currently a new type of acalculia could be found: using a pocket calculator acalculia; unfortunately, no neuropsychological test includes testing the ability to use a pocket calculator. We continue testing arithmetical abilities as if the procedures used to perform arithmetical operation had not changed since 1925, when acalculia was first systematically described by Henschen.

Recently, Tanaka and colleagues (2012) reported a case of "abacus-based acalculia." It is known that skilled abacus users perform mental arithmetic operations by manipulating a mental representation of an abacus. The authors studied the case of a patient who was a good abacus user, but transiently lost her "mental abacus" and arithmetic performance ability after a right hemispheric stroke including the dorsal premotor cortex and inferior parietal lobule. Seemingly, this is the first case report on the impairment of the mental abacus by a brain lesion. This case clearly illustrates that the brain organization of calculation abilities is contingent with the strategy and supporting devise that is used. Usually, calculation abilities are disturbed in cases of left inferior parietal lobule damage (Boller & Grafman, 1985; Dehaene, Spelke, Stanescu, Pinel, & Tsivkin, 1999), not right inferior parietal lobule, as reported in this unusual "abacus-based acalculia."

Memory

An Indian from the Amazonian jungle joked that non-Indian people had an extremely poor memory and that they had to be writing down everything on a paper (personal observation). Of course, written language is an extension of the semantic memory: We keep verbal memories not only in the hippocampus and the left temporal areas (as we have done for centuries; Jansen *et al*., 2009), but also in some external devices: Notebooks, books, diaries, and so on. In this sense, writing is an extension not only of oral language, but it is also an extension of verbal memory.

Experiential or episodic memory is the form of memory that allows an individual to recollect events and experiences from his/her past (Squire, 2004). It is also referred to as autobiographical memory. Information in experiential memory has a particular time and space location. Remote memory is the ability to recall events from the distant past (Squire & Bayley, 2007); that is, it is the ability to remember experiences and events that occurred years ago. Remote memories, including childhood memories, are imprecise, "blurred," and we are even not sure if they really existed (Hyman & Pentland, 1996). The introduction of photography, however, has radically changed our episodic autobiographical memories, including our remote memories. Frequently, we can reconstruct our past with photographs; furthermore, photographs are cues to evoke memories from the past (i.e., looking at a photography, many—seemingly forgotten—memories can be retrieved). That simply means that photographs represent external devises to keep memories (Fig. 6). Written language represents an auxiliary semantic memory devise; photographs represent an auxiliary episodic memory devise.

Fig. 6. Remote memories are imprecise, "blurred," and even we are not sure if they really existed. Photographs are precise, clear, and objective.

That is, the ability to store information has significantly increased as a result of the extended use of different external devises. These external devises can store not just verbal information (notebooks, books, diaries, computer memories, etc.) but also non-verbal information (photographs, etc.).

Spatial Orientation

Contemporary city life, in which direct orientation in space has been replaced by the logical application of mathematical coordinates, represents not just a recent cultural acquisition, but also it is found only in some contemporary human groups. For a very long time, education consisted of learning how to get oriented in the space, how to recognize the relevant signals to follow prey, and how to move in the surrounding environment (Foster & Purves, 2002). This, of course, is still valid for contemporary people living in the Amazonian jungle, for Eskimos, for desert inhabitants, and many other world inhabitants, especially for those living in rural areas (Istomin & Dwyer, 2009; Fig. 7).

People living in different environments develop different systems of spatial reference (rivers, mountains, sun position, streets, buildings, etc.); and differences in reference systems may, in turn, be related to differences in perception of spatial orientation (Pick & Pick, 1978). Evidently, members of different cultures dwelling in different spatial environments operate in terms of complex spatial reference systems, depending on their particular demands and geographic environments. By the same token, people living in different historical moments are exposed not only to different environmental conditions, but also to different orientation strategies and orientation devises (compasses, maps, GPSs, etc.).

Recent changes in spatial orientation requirements and needs are the result of two factors: (a) the urbanization process (Table 2) observed in all the countries in the world; rural people get oriented using different strategies (e.g., the sun, the rivers, the trees, etc.) than urban people (e.g., the name/numbers of the streets, the buildings, etc.; Richards, 1975); (b) the development of new strategies and technologies to get oriented (Fig. 8).

People Recognition

Recognition of own-species members represents a basic survival ability not only for contemporary man, but also for every living creature. Lacking this ability, any species would quickly disappear. Recognition of the own species members is based on a wide range of multiple sensory information. For instance, insects rely especially on olfactory information to identify other members of their own species, whereas primates use mainly—but not exclusively—visual information (de Waal, 2003; Hinde, 1974; Jolly, 1972; Rössler & Zube, 2010). In mankind, the critical and distinguishing signal features used in the recognition of other species members have somehow evolved in a parallel way with cultural evolution, as a result of the use of different clothes, costumes, paintings, hair-styles, make-ups, and so on. People also use a diversity of non-verbal behavior strategies to communicate a given intention without pre-established conventions (Noordzij *et al.*, 2009).

Brain organization of people recognition has been studied under normal and pathological conditions ("prosopagnosia"; e.g., Bodamer, 1947; Busigny & Rossion, 2009; Damasio, Damasio, and Van Hoesen, 1982). Prosopagnosia is associated with damage in the occipito-temporal area, either bilateral (e.g., Bruyer *et al.*, 1983; Damasio *et al.*, 1982; Ettlin *et al.*, 1992;

Fig. 7. Spatial orientation in a jungle, in a city, and when driving a car.

Table 2. Example of the urbanization process. Percentage of rural and urban population in the USA at the beginning and at the end of the XX century (Urban/Rural Census Data 1900 to 2000).

Year	Rural %	Urban %
1900	59	41
1950	40	60
2000	18	82

Meadows, 1974) or right (e.g., Benton, 1990; De Renzi, 1986). It is usually assumed that a bilateral occipitotemporal network mediates face perception (Minnebusch, Suchan, Köster, & Daum, 2009); when this network is disrupted, face recognition defects are observed.

Until recently in history, human contact was mostly face to face. Currently, to a significant extend we know (recognize?) other people by photographs and on TV. Of course, the quality of photographs and TV has progressively improved with the introduction of colors. TV allows movements and multiple perspectives. Photographs use a two-dimensional representation. Photographs, in addition to the lack of three-dimensionality, have another bias: they concentrate on the face; this means, most of the newspapers (and also books) photographs of other people are photographs of the faces, not the whole body.

Thanks to the extended use of newspapers and books, nowadays we have the possibility to know many more people than one century ago. We know how people of other countries look; we know artists, we know sportspeople, know politicians, we know scientists, and so on. Our social world has significantly extended during the last century.

Executive Functions

In the contemporary world, executive functions are strongly required for controlling some new technological instruments developed during the last century (Tirapu-Ustárroz, García-Molina, Ríos Lago, & Ardila, 2012) including home devises (e.g., the microwave oven; Fig. 9), transportation vehicles (e.g., driving a car or using the metro system), communication devices (e.g., cell phones, faxes), work devices (a diversity of new technological conditions may be required), and so on.

But, probably, the most important technological instrument currently used in a diversity of situations is the computer. Computers have become the most essential instrument in contemporary world. Computers have been around for a very short time, but their use has become so extended, that many people spend most of their working (and leisure!) time in front of a computer.

Using a computer is somehow akin to a new reading system. Obviously, there is not any brain area related to using computers, as obviously there is not any brain area related to reading and writing (Ardila, 2004). These are cultural and technological elements recently developed in human evolution. Rather, there are basic cognitive abilities that are required for the use of these new cultural elements: for example, certain visuoperceptual abilities and cross-modal associations for reading; phonological awareness and some fine movements for writing, and so on. Using computers is notoriously more complex, but anyhow, as in reading and writing, we can assume a "functional system" participating in using computers.

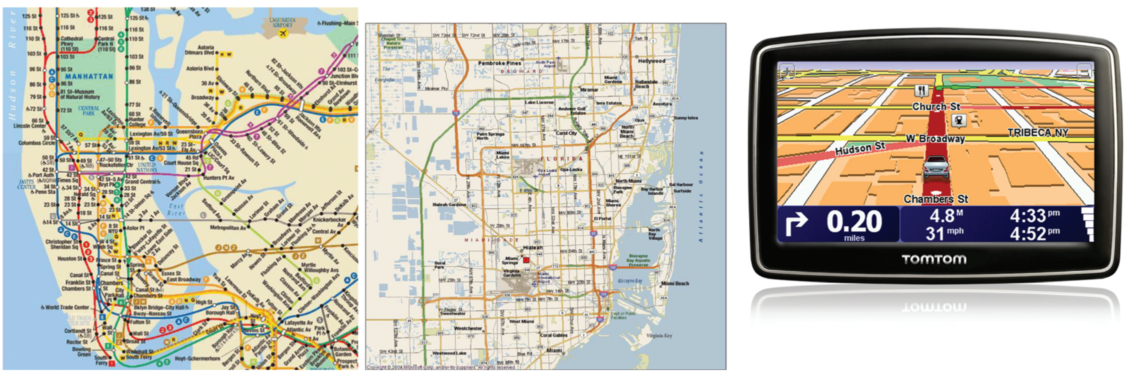

Fig. 8. New strategies and technologies to get oriented in space: a map of the New York City metro, a map of a city, and a map on a GPS (Global Position System).

Fig. 9. Using a microwave to heat frozen ready-to-eat food, requires different executive functions than using a fire and a pot.

It can be conjectured that using computers requires at least the following abilities:

- A conceptual ability (executive functioning) to understand the principles governing the functioning of computers.
- Some visuoperceptual abilities to recognize icons, windows, and so on.
- Some skilled movements to type on the keyboard and correctly moving the mouse.
- Some spatial abilities to handle the working space (monitor screen).
- Some memory abilities for learning to use new programs, and so on.

Few studies have analyzed the brain organization that computers use. Small, Moody, Siddarth, and Bookheimer (2009) performed a functional magnetic resonance imaging of the brain on 24 subjects (age, 55–76 years) during a search engine use and explored whether prior search engine experience was associated with the pattern of brain activation during Internet use. During the Internet search task, a control group showed an activation pattern similar to that of their text reading task, whereas the experimental group demonstrated significant increases in signal intensity in additional regions controlling decision-making, complex reasoning, and vision, including the frontal pole, anterior temporal region, anterior and posterior cingulate, and hippocampus. Internet searching was associated with a more than 2-fold increase in the extent of activation in the major regional clusters in the experimental group compared with the control group.

Obviously, the ability to use computers can potentially be impaired as a consequence of a disorder in any one of these abilities required to use them (kind of "acomputuria syndrome"). Different subtypes of acomputuria could be distinguished, corresponding to the abilities involved in computer use:

- Conceptual acomputuria
- visuoperceptual acomputuria
- apraxic acomputuria (apraxia for using the mouse and the keyboard)
- spatial acomputuria
- amnesic acomputuria

There is an additional point that should be mentioned with regard to the contemporary use of complex technological devises. Technological demands, especially multitasking demands, are particularly evident for younger people; it seems apparent that there is a tendency to simultaneously use different technological devises, resulting in a continuous interruption of different tasks. The constant interruptions from phones/text massagers, email, Bluetooth, and so on, may be taxing on the brain in a way that was not true in the past. It can be speculated that something has changed in the control of attention.

Technological changes have been related with increased abilities in certain cognitive domains. For instance, Flynn (2008) has speculated that the gains in fluid intelligence observed in different countries world-wide since several decades ago (so-called "Flynn effect") is a result of diverse cultural and technological innovations. Flynn refers to these transformations in how we think as "liberation from the concrete" resulting in more abstract thinking ("putting on scientific spectacles").

Finally, there is an important observation related to the recent introduction of new technologies. Due to the new scientific and technological conditions existing in the contemporary life, the world has become significantly incomprehensible. We use cars and planes in transportation; we cook using microwaves ovens; we take lots of chemical preparations (medicines); and we spend many hours weekly using a computer. However, how many people could answer to the following obvious questions?

- Why would fly planes?
- Why microwave ovens heat?
- Why aspirin relieves the pain?
- How a gasoline motor works?
- Where is the Internet information stored?

(Personally, I am not sure if I could answer more than one or two of the questions above!)

Conclusions

A significant interest in understanding cultural differences in neuropsychology has been observed during recent years (e.g., Fletcher–Janzen, Strickland, & Reynolds, 2000; Uzzell, Pontón, & Ardila, 2007). However, it is time to compare neuropsychological syndromes and neuropsychological testing procedures not only across cultures, but also across time. Most of the neuropsychological syndromes were described during the late 19th and early 20th century, and living conditions have dramatically changed during the last 100 years. It can be proposed that it is time to re-analyze most of the neuropsychological syndromes, and eventually, to develop new assessment procedures, more in accordance with the XXI century living conditions. It is easy to hypothesize that new technological conditions have changed the brain organization of cognitive functions; we obviously need empirical clinical evidence to support this assumption.

Conflict of Interest

None declared.

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