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THE NEXT FRONTIER – NEUROSCIENCE OF EDUCATION

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The Next frontier – Neuroscience of Education

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Abstract

The recent advances in neuroscience and the educational research may work together – a neuroscientific perspective adds a new dimension to the study of learning, and educational knowledge could direct the neuroscience research towards relevant areas. Researchers and educators may work together to identify educationally-relevant research goals and discuss potential implications of research results. Educational neuroscience is necessary for defining a real science of learning.

This could be entitled the “neuroscience of education”, based on some of the current issues associated with bioinformatics or neuroinformatics and fMR imaging. The neuroimaging methods could be a valuable tool in the process of understanding the cortical processes that undergo learning.

Keywords:

Neurosciences, neuroimaging, education, learning,

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Introduction

Which is the reason why education – that is supposed to be a science – is so far from science? More than one hundred years passed since the theory of quantum mechanics was formulated, and we still think and teach in Cartesian terms. We still think that knowledge is the sum of the information we have, we still consider our cells like bags filled with weird things that bear sophisticated names. “The world is quantum mechanical: we must learn to perceive it as such”, says Richard Conn Henry, because “one benefit of switching humanity to a correct perception of the world is the resulting joy of discovering the mental nature of Universe”.

Methodology

The practical aspects of data collection, analysis, interpretation, and the management of large data sets are considered, in order to adopting of EEG (electroencephalography), of functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and single-photon emission computed tomography (SPECT) into a new science of education. Psychological functions have been assigned to certain brain areas using electroencephalography (EEG), magnetencephalography (MEG), PET or fMRI. There are no inactive areas in the brain – even asleep, no brain area is completely inactive. \

Electroencephalography (EEG) is the recording of electrical activity in the brain along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain (Niedermeyer & da Silva, 2004).

fMRI uses BOLD (blood oxygen level dependent) contrast to map neural activity in the sensory regions of the brain, and even its cognitive functions. fMRI relies on the paramagnetic properties of the more or less oxygenated haemoglobin to offer images of the blood flow in the brain, a flow that varies with the activation of the neurons.

PET uses a radiolabelled compound (radiotracer) which is injected into the bloodstream. Its radioactivity is detected by sensors in the PET scanner, and the emissions of the radiotracer are computer processed to produce 2D or 3D images. The most common radiotracer is a labeled form of glucose – glucose is the best “fuel” for the brain, hence when a specific cerebral region becomes active, it requires more glucose.

SPECT is similar to PET – it uses gamma ray emitting radioisotopes. A radioactive tracer (SPECT agent) is injected into the bloodstream, a gamma camera records data, and a computer produces two or three dimensional images of the brain regions which are active. Compared to PET and fMRI, SPECT offers a snapshot of the cerebral flow, but a poor resolution.

The images acquired during a neuroimaging session are then interactively postprocessed to produce an activation map. This map may be interpreted by clinicians. The neuroimaging methods could be a valuable tool in the process of understanding the cortical processes that undergo learning.

Why “neuroscience of education”?

Connecting cognitive neuroscience and teacher education is not a recent endeavour – the idea of “neuroeducators” was proposed in the 80’s, when the study of brain / behaviour was considered a way to enhance the pedagogical practice (Cruickshank, 1981).

To connect classroom experience and cognitive neuroscience in a holistic manner (inter-, intra-, transdisciplinary), a better communication between the two fields is needed. Lately, “mind, brain and education” (MBE) has become an option, but this approach still excludes essential details of the human behaviour – the influence of the hormones in a stressing situation, for instance, and the development of the human being as a whole, not only as a brain.

The recent advances in neuroscience and the educational research may work together – a neuroscientific perspective adds a new dimension to the study of learning. Likewise, the educational experiences could direct the neuroscience research towards relevant areas. Researchers and educational trainers may work together to identify educationally-relevant research goals and discuss potential implications of research results.

Neurosurgeon Alan Crockard has coined, in the early ‘80s, the term “neuromyth” to define non-scientific ideas about the brain (Crockard, 1996). In 2002, the Brain and Learning project of the UK’s Organization of Economic Cooperation and Development (OECD) redefined the term “neuromyth” as “misconception generated by a misunderstanding, a misreading or a misquoting of facts scientifically established (by brain research) to make a case for use of brain research in

education and other contexts” (OECD Publications, 2002). Some of those neuromyths, as listed by OECD, are:

- “people are either right or left brained”, hence, people are either logical, or creative – The question is what means “logical” or “creative”? According to a theory of education, the left hemisphere – the “logic” one – will deal with math skills. The ability to deal with numbers comes from processing that undergoes in both hemispheres; the left hemisphere seem to be more involved in counting and reciting multiplication tables, which rely on memorized verbal information (which is considered as “logical”), and the right hemisphere is “better” in estimating. Both hemispheres make critical contributions for most of cognitive skills. “It takes two hemispheres to be logical / creative” (Federmeier, Wlotko, Meyer, 2008). The “left or right brain” myth originates in the misinterpretation of neuroimaging studies – the well-defined bright-spots on one side of the brain indicate, in fact, a statistical map that shows where the activity has exceeded an arbitrary threshold.

- “the first three years of a child are decisive for later development and success in life, because the brain is only plastic for certain kinds of information during specific critical periods” – this idea originated from studies of Konrad Lorenz’s critical period of imprinting in birds. The critical periods, though, are not so sharply delineated and are influenced by many factors. Most of the research in vision, audition and language show that different brain systems display very different amounts and types of changes with experience – this quality is named plasticity and measures the capacity to form synapses. The ability to learn the sounds and the grammar of a language appears to be optimal in the early and middle childhood years, but some systems keep changing with experience throughout life, and plasticity is not limited to the first three years of existence. Any kind of stimulation induces new connections between neurons, and this ability is conserved throughout whole life.

- “enriched environments’ enhance the brain’s capacity for learning”, hence, one of the theories of educations states that if a child has not been fully exposed to an enriched environment, it will not recover later on in life and his capacities that could be accomplished early in life are lost. The idea comes from a research on rats – those raised in an enriched and stimulating environment could solve and learn complex maze problems compared to rats raised in a deprived environment, which never recovered after moving them in an enriched

environment. Human brain shows plasticity throughout the whole life and is not limited to an “enriched” environment phase during the first three years of life (Goswami, 2004). The concept of “enriched environment” is, by the way, arguable, as long as the beings – human or not – fully develop in their natural environments. There is a full body of research in the field of animal cognition, which shows that animals can learn to talk in human language if necessary...

- “there is a visual, auditive and a haptic type of learning” – this is the ‘type of learner’ theory, and was formulated by Frederic Vester in his book, *Thinking, Learning, Forgetting*, first printed in 1975. This theory states that learning occurs through different ‘channels of perception’, and the type of learner – biologically determined – can be characterized by the predominant use of one channel of perception. As scientist stated, a step beyond perception is necessary – the learner needs to process the input of his senses and give this input a meaning, and this is the essential step in understanding and learning. Another Cartesian approach is Howard Gardner’s theory of multiple intelligences – although useful in stimulating people to “unpack their gifts”, it may block the fully manifestation of the intelligence itself, as a result of the human potential as a whole. In our days, this “learning style” theory is still the most praised. The origin of this myth is the idea which stands that as long as different regions of the cortex process different types of stimuli, students should receive information in visual, auditory or kinaesthetic forms, according to the part of the brain they use better (Politano & Paquin, Portage & Main, 2000). There is no scientific data to support this idea (Coffield, Moseley, Hall & Ecclestone, 2004; Geake, 2008; Kratzig, & Arbuthnott, 2006).

- “we only use 10% of our brain” – one of the most stated brain myths, is still in use. All existing data shows that we use a 100% of our brains. There are more than one sources of this myth: the ratio of glia cells to neurons in the brain (10:1); the studies of Karl Lashley who explored, at the beginning of the XX-th century, the function of certain brain areas using electric shocks. Many brain regions did not react, hence, he concluded that these regions did not have any function; it seems that Albert Einstein told to a journalist that he only used 10% of his brain, as an answer to a question concerning his intelligence, but there is no official record of this statement...

- two languages compete for resources – the more one language is learnt, the more the other language is lost; knowledge, acquired in one language, is not accessible in the other language – the two languages lie next to each other in separated brain areas, with no points of contact; knowledge acquired in one language cannot be transferred to the other language; the first language must be spoken well, before the second language is learnt.

There are brain areas specialized to deal with language, and which are crucial for performing language tasks, but different parts of both right and left brain hemispheres are active during language production as well. In multilingual individuals, there is a great deal of similarity in the brain areas used for each of the languages they use. Bilinguals monitor continuously their languages in order to avoid unwanted language interferences from the language not in use and this, in turn, induces plastic neural effects. This may be the reason why bilinguals are faster than monolinguals on many control tasks that involve attention (Abutaleb, Della Rosa, Green, Hernandez, Scifo, Keim, Cappa & Costa 2012).

There is a trend, right now, in creating reward games to improve learning (Howard-Jones, Demetriou, Bogacz, Yoo & Leonards, 2011). The main idea consists in “offering uncertain rewards to increase midbrain dopamine uptake” (Fiorillo, 2011). In order to increase the rate at which curriculum material is learnt (Ozcelik, Cagiltay & Ozcelik, 2013). There are teachers claiming that “a good working environment will release dopamine, and then they [the students] feel good and it is remembered as something positive” (Soni-Garcia, & Howard-Jones, 2014). The media promoted dopamine as the reason for addictive behavior, and the public just took this for granted.

This is why understanding the brain and its connections with the whole body may help the dialogue between Education and Neurosciences.

Conclusions

Bridging the gap between Neurosciences and Education seems too far to be achieved. A conference on Early Education and Human Brain Development (Santiago, Chile, 2007) ended with this statement: “neuroscientific research, at this stage in its development, does not offer

scientific guidelines for policy practice or parenting” (McDonnell Foundation, 2007).

The contribution of the neuroscientific community to a better understanding of the human activity of learning for educational purposes is crucial, though, and it applies for all – no matter the gifts or the age. These contributions may help for a better understanding of:

- optimal timing for different forms of learning, especially in relation to adolescents and older adults.
- neurobiological mechanisms which underlie the impact of stress on learning and memory. A specific question concerns the adolescent’s emotional brain interactions with different kinds of classroom environments.
- mechanisms nutrition / physical exercise / sleep / art impact on brain development;
- types of learning and cultural differences;
- multi-dimensional pathways to competences – in reading, for instance;
- “mathematics anxiety” and other barriers human being raise itself in an educational environment;
- different brain activity – neural networks, role of cognitive function and memory;
- role of the immune system in the learning and teaching process.

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Biodata



Adriana BRAËSCU is a Biologist involved in the Education reform in Romania. Since 2013 she is a PhD student at the Faculty of Biology, University of Bucharest.

She holds a BSc in Biology (1994) and an MD in Neurobiology (1995) from the University of Bucharest. While a student, she had the opportunity to work as intern in the labs of the Life Science Department, University of Nottingham, UK.

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Since 2013 she founded RE-DESIGN association, a NGO that promotes a change of paradigm in Education. She develops interdisciplinary courses – a mix of science, philosophy, history and art, to provide a comprehensive approach of knowledge.