Brain Mechanisms and Early Learning

Highlights of the First High Level Forum on Learning Sciences and Brain Research

Synthesis by Sonia Jurich

In the past decades science has made remarkable progress in our knowledge about the brain, its anatomy and physiology. However, this progress is yet to influence educational theories and practices. In 1999, the Organization for Economic Co-operation and Development, Centre for Educational Research and Innovation (OECD-CERI) outlined the project “Learning Sciences and Brain Research: Potential Implications for Education Policies and Practices.” The project focused on creating a bridge between researchers in brain and learning sciences and fostering collaboration among scientists, practitioners and policy makers. This dialogue is essential to promote a new understanding of the learning processes that incorporate recent scientific advances, encourage value-added discoveries and improve the knowledge base for decisions on education policies and practices.

The project included three high level meetings. The first meeting, held at the Sackler Institute in New York City, in June 2000, discussed research on “Brain Mechanisms and Early Learning.” The forum on “Brain Mechanisms and Youth Learning” occurred in February 2001 in Granada, Spain. The third forum, on “Brain Mechanisms and Learning in Ageing,” took place in Japan, in April 2001.

This article presents highlights of the forum on “Brain Mechanisms and Early Learning.” A preliminary report of this forum can be accessed on the web site: http://www.oecd.org/els/pdfs/EDSCERIDOCA086.pdf

Names and page numbers cited in this article refer to the online report.

The forum highlighted the following areas of research:

Brain Plasticity

- The brain is composed of neural systems that differ in their anatomy, physiology and location. These systems collaborate to produce higher cognitive abilities, such as language and mathematical reasoning.
The structure of the brain is not pre-determined. Learning is shown to promote permanent physical changes in the brain, including an increase in the numbers of connections (synapses) among neurons and a proliferation of blood vessels and support cells in the areas involved in the process.

**Brain Periodicity**

- Learning of some abilities are tied to “sensitive periods” during which the brain region (or regions) responsible for the learning process are maximally modifiable.

- If the exposure to relevant nurturing or experience occurs after the sensitive period, learning still takes place, but the brain uses different and potentially less adapted methods to process the information. In this case, the individual may have more difficulty to acquire the skill or may not be able to master the skill. Language acquisition (see below) provides a good example of brain periodicity.

- Depending on the presence or absence of sensitive periods, Greenough divides learning into two types: experience expectant, where the relevant experience must occur within a determined window to optimize learning; and experience dependant, where learning is independent of the time of the relevant experience (p. 7).

- Educational policies that offer learning opportunities at appropriate periods can maximize the learning process for all children, even those who live in environments less conducive to learning.

**Early Cognition**

- Cognitive observations of infants indicate that children are born with specific knowledge and skills. These innate structures are not unchangeable, as previously supposed, but evolve significantly during early childhood.

- Piagetian psychology proposed that young children did not have the structure to comprehend complex or abstract phenomena, such as those related to physics or biology. However, research with infants as early as 4 months old indicates the presence of “highly abstract predictive generative models” (Gopnik, p.9) concentrated in four areas of knowledge:

  - **Everyday psychology** – infants develop rudimentary theories about people’s behaviors and react to people accordingly.

  - **Everyday physics** – how objects move and how to interact with objects is another area that fascinates young children.

  - **Everyday biology** – young children are attracted by living things, such as plants and animals, and create explanations for their different behaviors.

  - **Language** – learning a language is an essential activity during early childhood.

- Gopnik suggests that early childhood education, rather than shy away from teaching science, should capitalize on the areas that are at the center of interest of young children.

**Emotional Competency**

- Research shows that emotion and cognition occur within the brain at the same time but utilize different structures. The interaction between the two processes - emotion and cognition - determines the individual’s behavior.

- The processing of emotions is the responsibility of the limbic system, a group of structures buried within the brain. These structures participate in the emotional assessment of life situations and organization of appropriate responses, an ability that is essential for successful integration into society.

- The emotional process is broad, automatic and unfiltered by attention (impulsive). Therefore, a balanced communication between the emotional and the cognitive parts of the brain is essential for social success. Academic success depends equally on cognitive abilities and on the ability to deal with frustration, stress, task perseverance and concentration, that is, the ability to exert self-control (an emotional skill).

- Research with children from low-income areas indicates that their emotional childhood abilities are best predictors of late success in life, rather than their IQ. However, formal education emphasizes cognitive abilities while omitting the importance of the “emotional brain.”

- The study of the emotional brain is still in its beginning. As the knowledge of the neural basis of personality traits expands, new interventions that teach emotional competency and self-regulation may be developed, thus promoting an educational system that can promote both cognitive and emotional competency.
Specific Learning Processes

Language Acquisition

- This is a complex process that implies both experience dependent and experience expectant mechanisms.

- Semantic information, or the acquisition of new vocabulary, is experience dependent. This type of learning is always processed through bilateral posterior regions in the brain, independent of when the experience occurs. That is, people learn new vocabularies the same way regardless of whether they are small children or older adults.

- The learning of grammar, though, depends on a sensitive period (experience expectant). When the learner is younger than 13 years old, only the left hemisphere is involved in the process. As the learner ages, both hemispheres are activated. Learners who use both hemispheres have more difficulty mastering grammar than those who use the left hemisphere only. That is, older individuals will have the same ability to learn new vocabularies in a foreign language, but difficulty to learn grammar.

Reading

- Research with adults who have difficulty reading (dyslexic) suggests impairment of the brain structures that are involved in decoding sounds. Researchers obtained brain images of dyslexic and normal adults during a reading section. Adults with dyslexia fail to recruit some regions of the brain that are activated in the normal adults who are focusing on the sound structure of the words.

- The mechanism to decode new words, converting letters into sounds in order to pronounce the word adequately, is present in non-dyslexic children at early ages. In children who have difficulty reading, this mechanism is impaired. The children can learn words that are given to them visually and recognize the words in later time, but are unable to generalize the learning when confronted with new words.

- “Minimum word pairing” is a process that uses basic decoding skills to teach dyslexic children how to sound words. A sequence of words is offered that differ from one another by one letter or “grapheme.” The children start with small sequences and gradually work their way to larger sequences and more words. Eventually, they learn the idea of combining sounds and words, the basic principle for learning how to read.

Mathematics

- Learning mathematics involves different areas of the brain and may include a visual subsystem (the fusiform gyrus that is located under the brain), a verbal subsystem (regions of the left hemisphere) and the quantity subsystem (interparietal lobes). Impairments in any of those subsystems or their inability to coordinate information may cause problems with learning mathematics.

- The quantity representation subsystem is independent from language and is present in infants as young as 4 months old. Teaching mathematics without verbalization, such as the Montessori process, helps children who are having difficulty connecting the quantity and the verbal subsystems.

- The Right Start program, which uses physical objects as a spatial analogue of numbers has been successful in teaching mathematics even when the children cannot read.

Cognitive psychologists observe the brain from the “outside” to propose hypotheses about the mechanisms that may explain learning behaviors. Neuroscientists observe the brain from the “inside” to directly confirm those hypotheses and/or establish new ones. The cooperation between cognitive psychology and neuroscience expands the theoretical basis through which educators can derive more successful teaching and learning practices and provides policy makers with a sound framework on which they can base educational policy decisions.

First High Level Forum on Learning Sciences and Brain Mechanisms

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1 The next issue (November/December 2001) of *Techknowlogia* will deal with the topic of Technology for Language Acquisition. Included will be a follow-up article on Brain Mechanisms for Language Acquisition.