Connecting Brain and Behavior in Educational Research

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Educational neuroscience is a fledgling new area of educational research that augments traditional methodologies in educational research with methods and tools from cognitive neuroscience and psychophysiology. The Educational Neuroscience Laboratory in the Faculty of Education at Simon Fraser University has been conceived and designed to help establish this new area. In this article I report on a number of projects currently underway in the lab. These projects include refining our theoretical frameworks, developing new analytical methods, and a variety of educational research applications ranging from studies in ESL anxiety and geometric image-based reasoning to metacognition and mathematics education in virtual environments. Although all of these projects are on-going or in various stages of completion, this overview demonstrates that educational neuroscience is affording new opportunities for educational research.

In this paper I briefly report on the background, conception, design, and development of the ENGRAMMETRON, a new educational neuroscience laboratory in the Faculty of Education at Simon Fraser University, a laboratory that has been established for new opportunities and directions in educational research [1]. I then report on a number of collaborative projects that are currently underway and in various states of completion. These projects include refining theoretical frameworks, developing new analytical methods, and a variety of educational research applications ranging from studies in ESL anxiety and geometric image-based reasoning to metacognition and mathematics education in virtual environments. Specifically, here, I offer brief reports on the following projects.

1) Embodied cognition
2) New methods for old problems
3) Multistable perceptions and geometric image based reasoning
4) Metacognition and motivation in self-regulated learning
5) Mathematics education in virtual environments
6) Learning biofeedback
7) ESL anxiety
8) On neuropedagogy and the importance of outreach

Embodied cognition [2] is an on-going project concerning the theoretical framework that guides and justifies all of our activities in the lab. It is a non-dualist view of cognition and learning that acknowledges the embodiment of human subjectivity. Explicating, situating, and expanding upon this view is of the utmost importance in our efforts to bring educational neuroscience into the mainstream of educational research. Embodied cognition is the basis upon which we address questions pertaining to the educational relevance of studying brain and body as part and parcel of our studies in cognition, affect, and learning. It is appropriate, then, for us to begin with a brief report on our work in this area.

Establishing a new approach to educational research, in addition to a soundly developed theoretical framework, typically involves new methodologies. This is most certainly the case for educational neuroscience. The approach we are taking to educational neuroscience in the ENGRAMMETRON involves the use of electroencephalograms (EEG), electrooculograms (EOG), electrocardiograms (EKG), eye-tracking (ET), to mention a few of the most notable data sets, integrated in a time-synchronous manner with more traditional audiovisual (AV) data sets. It is also appropriate, then, to report on some of the new methods we are working with.

One of the central topics the ENGRAMMETRON has been designed to research is the nature of mathematical cognition and learning. When a learner is looking at a geometrical diagram, that much is obvious. How do we know what part of the diagram a learner is looking at in any given moment? How do we gain insight, verbal reports aside, as to what they are thinking and when? One of the most intriguing areas of study in this regard concerns mathematical pattern recognition and mathematical concept formation. Toward this end, I report on our pilot study investigations into multistable perceptions and geometric image based reasoning.

The first major project the lab has undertaken has been a study on metacognition and motivation in self-regulated learning. Data acquisition for this project is in its final stages with over a hundred participants thus far, and data analysis is also well underway. The experimental design of this project involves participants' study of a basic theorem of number theory, and as such, the large data set collected as part of this project has implications for mathematics education research as well. I present and discuss some preliminary results from this study.

The methods we use in the ENGRAMMETRON are particularly well suited for investigating learners' interactions with visual stimuli presented on a computer monitor. With the internet becoming so ubiquitous, we are well situated for studying the latest innovations on the web. One of these is the emergence of virtual reality environments. Here I report on a project initiative to implement and study various aspects of mathematics education in such an environment.

An important dimension of educational neuroscience is to explore to what extent we are capable of placing ourselves in brain and body states and processes that are most conducive to various aspects of learning, such as memorizing, remembering, imagining, reasoning, and general states and processes associated with "brain-storming" and other kinds of problem solving activities. One avenue into such matters could be to use biofeedback and neurofeedback techniques to explore such states a processes. As a first step in this regard, I report on a project investigating how well a gaming environment can help participants learn biofeedback.

One contribution of the brain sciences over the past few years is growing evidence for the importance of affect in cognition and learning. It is now well known that affect can impede or improve learning. One of the major ways in which affect can impede learning is through anxiety. Anxieties can come in many forms, and two forms that we are most interested in understanding and unraveling are math anxiety and English as a Second Language (ESL) anxiety. In this paper, I report on one pilot we are running on ESL anxieties in Iranian women in Canada.

We are not pursuing research in educational neuroscience for the sake of pursuing research. Our aim is to make a positive

difference for teachers and learners in classroom environments. There is a huge divide between the neurosciences and education, and there are great differences between neurons in the brain and kids in classrooms. Our research in educational neuroscience aims to help bridge those differences through a more informed and less speculative approach to "brain-based education" that we are referring to as neuropedagogy. Closely aligned with this approach is a viable outreach program that includes various stakeholders and interest groups concerned with neuroscience and education.

References

1. Campbell, S. R., & the ENL Group (2007). The ENGRAMMETRON: Establishing an educational neuroscience laboratory. *The SFU Educational Review* **1**, 17-29.
2. Varela, F., Thompson, E., & Rosch, E. (1991). *The embodied mind: Cognitive science and human experience.* Cambridge, MA MIT Press.