HOW CAN COGNITIVE NEURO-SCIENCE CONTRIBUTE TO MATHEMATICS EDUCATION? FOCUSING ON PROBLEM SOLVING AND CREATIVITY IN MATHEMATICS

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Since 1998, when Byrnes and Fox suggested that brain research findings might have useful applications in education, many researchers have not only supported this opinion theoretically, but have made an effort to apply the obtained neurocognitive data to the development of educational theory and practice, including the field of mathematical cognition. A considerable body of research has been performed towards gaining an understanding of the neural foundation of numerical cognition and, to a lesser extent, of more advanced mathematical thinking and learning in the fields such as symbolic manipulations, translations between representations of functions and geometry problem-solving (De Smedt & Verschaffel, 2010).

From the position of a mathematics education researcher I will present meta-analysis of the neuro-cognitive research associated with mathematical processing. The analysis will be mainly focused on neuro-imaging research that investigates topographies and magnitudes of brain activation during mathematical processing of different types (e.g., arithmetic operations, symbolic manipulations, translations between representations of functions and geometry problem-solving). Special attention will be given to the neural efficiency hypothesis (Neubauer & Fink, 2009) which states that brighter individuals display lower and, therefore, more efficient brain activation while performing cognitive tasks. Our research group draws a distinction between students' excellence in school mathematics and their general giftedness, and a distinction between algorithmic, strategic and creative problem solving, wherein creative problem solving is associated with mental flexibility and mathematical insight. Based on these distinctions, I will exemplify and discuss connections between the neural efficiency effect, the mathematical proficiency of problem-solvers, and the level of problem difficulty as related to mathematical insight required for problem solution.

Analysis of our research demonstrates that examination of the behavioral measures related to solving mathematical problems may be insufficient and even misleading and that neurocognitive analysis is crucial for understanding of mental processing associated with solving different types of problems in groups of students with different mathematical achievements (e.g., Leikin et al., 2014). In concluding the lecture I will outline some new research directions that can lead to validation of the theories in mathematics education and will argue that such research requires collaboration of mathematics educators and cognitive neuroscientists.

References

Byrnes, J.P., & Fox, N.A. (1998). The educational relevance of research in cognitive neuroscience. *Educational Psychology Review*, 10 (3), 297-342.

De Smedt, B., & Verschaffel, L. (2010). Traveling down the road: From cognitive neuroscience to mathematics education ... and back. *ZDM Mathematics Education*, 42, 649-654.

Leikin, M., Waisman, I. Shaul, S. and Leikin, R. (2014). Brain activity associated with translation from a visual to a symbolic representation in algebra and geometry. *Integrative Neuro-Science*, 13(1), 35–59.

Neubauer, A. C., & Fink, A. (2009). Intelligence and neural efficiency. *Neuroscience and Bio-behavioral Reviews*, 33(7), 1004-1023.