Mathematical Cognition and its Cultural Dimension

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Recent research has uncovered an increasing range of mathematical notions that are accessible to intuition. Numerosity, for instance, may be represented in an analog magnitude code that we even share with non-human species (Feigenson, Dehaene & Spelke, 2004). Similar findings are documented for topological and other geometrical notions (Dehaene et al., 2006). For precise operations, however, these intuitions need to be framed into more elaborate representations, and the way in which they are represented and the emphasis placed on them varies across languages and cultures.

Even so simple an act as precisely assessing numbers requires a cultural representation, namely a counting sequence (Frank et al., 2008; Gordon, 2004; Wiese, 2003). The number words of which such sequences consist constitute distinct numeration systems with specific properties and do not only provide indispensable tools for counting and calculating, but may also affect the way in which numbers are processed (Chrisomalis, 2004; Fuson & Kwon, 1991; Miller et al., 1995; Nickerson, 1988; Schlimm & Neth, 2008; Zhang & Norman, 1995). The mathematical domain thus offers a great opportunity to study interactions between culture and cognition—a research agenda that is increasingly recognized as one of prime interest for cognitive science.

In their attempt to unravel these interactions, the contributions to this symposium will focus on several related topics—the cognitive architecture for mathematical cognition, the evolution of mathematical representations and cognitive skills, or the impact of representations on the cognitive processes—and they will do so from various perspectives, drawing on findings and insights from anthropology, cognitive sciences, linguistics, and psychology. Among the core questions to be addressed are the following:

(1) Which of our mathematical competencies are intuitive, and to what extent do they depend on cultural representations?

(2) How strongly do the properties of these representations affect cognitive processing?

(3) And how have characteristics of cognitive processes enhanced or constrained the development of culture-specific representations?

In order to answer these questions and to disentangle the intricate relationship of mathematical notions, cultural representations, linguistic phrasing, and cognitive processing, this symposium brings together researchers from different disciplinary backgrounds. It is co-organized by an anthropologist and a psychologist who will give an introduction to the symposium's topic by summarizing some of the cognitive implications that culture-specific representations may have for numerical cognition (e.g., Beller & Bender, 2008; Bender & Beller, 2007). The presenters are among the leading scientists in their fields and have contributed considerably to the expanding knowledge on mathematical cognition in the form of comprehensive monographs and articles in high ranking journals such as *Cognition, Lingua*, or *Science*:

- Psychologist Marc Brysbaert of Ghent University has worked on basic numerical processes and how these may be affected by linguistic representations (Brysbaert, 2005; Brysbaert, Fias & Noël, 1998; Reynvoet & Brysbaert, 1999).
- Last year's winner of the Dr. A. H. Heineken Prize for Cognitive Science, Stanislas Dehaene from CNRS in Paris, has published extensively on the cognitive architecture of numerical cognition and on mathematical intuitions in cultures without mathematical vocabulary and education (e.g., Dehaene, 1997; Dehaene et al., 2006, 2008; Pica et al., 2004).
- And linguist Heike Wiese from the University of Potsdam has analyzed the status of counting words as language-dependent numerical tools and their co-evolution with numerical cognition (Wiese, 2003, 2007).

How Do People Process Numbers?

Marc Brysbaert

This talk gives a review of the cognitive processes underlying number processing. The first part includes a summary of the main variables affecting number processing times, namely the magnitude of the number, the distance to the previous number, and spatial information activated by the number. This is followed by an overview of the current ideas about the impact of the numerical format (verbal, Arabic, analogue) and the relationship between number processing and language processing.

Arithmetical and Geometrical Intuitions Without Mathematical Education in Amazonian Indians

Stanislas Dehaene, Véronique Izard, Pierre Pica & Elizabeth Spelke

"Intuition" is knowledge that we deploy spontaneously, effortlessly, and without any awareness of its origins. Our proposal is that mathematical intuitions are grounded in evolutionarily ancient representations of space, time and number that we share with other animal species and that emerge early in development. We will present evidence that adult Amazonian Indians, even in the absence of any mathematical vocabulary and education, possess clear intuitions of the relations between number and space—albeit of a logarithmic nature, similar to those of young children in our culture. Furthermore, when introduced with an appropriate mental model, they exhibit a surprising mastery of basic Euclidean and even non-Euclidean geometries—although Euclidean concepts appear to be most intuitive.

Numbers as a Culture-Driven Adaptation

Heike Wiese

I present a view of numbers as cognitive tools that are adapted to human cultures: While all cultures have the same options to employ different aspects of numerical cognition, they make use of these options selectively, leading to culture-dependent variation and to developmental paths that lead from less complex to more complex number systems as well as vice versa. I show that the human number concept makes use of two main systems, supporting (1) the perception of quantity, based on iconic representations of set sizes, and (2) the grasp of numbers as cognitive tools that can assess cardinal, ordinal, and nominal relations. I discuss examples from different human cultures that provide evidence for the selective realization of different aspects involved in these two systems.

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