In summary, we follow Feigenson *et al.*'s proposal to distinguish two core systems of number. In addition we offer a specific theory of how symbolic and approximate number representations can develop and the relation between them by describing how one and the same system can behave differently depending on the type of input: in an approximate way with non-symbolic stimuli, in an exact way with symbolic stimuli.

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Letters Response

Origins and endpoints of the core systems of number. Reply to Fias and Verguts

Lisa Feigenson[1], Stanislas Dehaene[2] and Elizabeth Spelke[3]

[1]Department of Psychological and Brain Sciences, 3400 North Charles Street, Johns Hopkins University, Baltimore, MD 21218, USA
[2]INSERM, Unit 562, Service Hospitalier Frédéric Joliot, CEA/DSV/DRM, Orsay, France
[3]Department of Psychology, William James Hall, Harvard University, Cambridge, MA 01238, USA

Fias and Verguts [1] raise two important issues: (1) what does it mean for core number systems to be innate, and (2) how can these representations underlie the symbolic system of exact number evident in human adults?

We are generally sympathetic with Fias and Verguts' efforts to find minimal starting conditions under which a neural system sensitive to number can develop, and to ask how this system might capture the behavioral findings we reviewed [2]. However, it would be misguided to think that Fias and Verguts have produced a purely empiricist alternative to the view that core systems of number are part of our evolutionary heritage. Even prior to learning, their model [3] is structured in a way that can only be described as numerical. It supposes a visual scene already parsed into discrete objects, and contains highly specialized 'summation nodes', similar to those first postulated by Dehaene and Changeux [4], that respond to total object number, regardless of object size, location or identity. And it injects Weber's law by assuming that the activity of these nodes is normalized to a fixed sum of squares. Without this last assumption, all numerosities would be equally discriminable regardless of their size. Thus, although the model might be useful in describing how the tuning of numerosity-detecting neurons evolves, it cannot be described as an unstructured network from which numerical sensitivity spontaneously emerges.

With regard to the acquisition of number symbols, Fias and Verguts make an interesting proposal: that the same bank of neurons might encode approximate number with a broad tuning curve when activated by an object array, and encode exact number with a narrow tuning curve when activated by a numerical symbol. We welcome this more precise and testable specification of what is meant by an 'exact' number representation. It remains to be seen whether this assumption will capture the available data (for example, the highly similar performance observed in numerical comparison with Arabic digits and with dot arrays [5,6]). However, it is clear that the model cannot fully capture several key pieces of developmental data. Most importantly, it does not explain why children must slowly and painstakingly master the meanings of the number words 'one', 'two' and 'three', before showing a sudden insight into the meaning of count words above 'three' [7]. Further, the model offers little insight into how children discover the discrete infinity of numbers. In our view, how children master the system of symbolic number and how this system relates to the two core systems shared with infants and other animals is still very much an open question.

Thus, although we differ with Fias and Verguts on both the theoretical implications of their model's performance and on its ability to account for the existing data, we strongly agree with their point that there is a need for a neuronal model of numerical development that can explain how semantic knowledge of number is encoded in the brain.

Corresponding author: Lisa Feigenson (feigenson@jhu.edu).

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