Individual differences in inhibitory control and fraction learning

David M. Gómez[1,2], Gonzalo Mena-Carrasco[1,3], Roberto Araya[1], Pablo Dartnell[1,3,4]

(1) Centro de Investigación Avanzada en Educación, Universidad de Chile, Santiago, Chile
(2) Settore di Neuroscienze Cognitive, Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italia
(3) Departamento de Ingeniería Matemática, Universidad de Chile, Santiago, Chile
(4) Centro de Modelamiento Matemático, Universidad de Chile, Santiago, Chile

Understanding the interplay between educational practices and individual variability in cognitive capacities is a cornerstone for the development of appropriate methods to complement the teacher's work in the classroom. A cognitive capacity that has started to be considered in the context of mathematics education is inhibitory control: Some researchers (e.g. Bull & Sceriff, Developmental Neuropsychology, 2001; Clark, Pritchard, & Woodward, Developmental Psychology, 2010) have noticed that children with better inhibitory capacities tend to outperform their peers. However, these authors only evaluated general mathematics achievement, limiting the possibilities of interpreting their data in more precise, mechanistic lines. A specific area in mathematics in which inhibition of pre-automatized strategies may play an important role in learning is the early instruction of fractions, where the intrusion of well-known facts and strategies about whole numbers leads to wrong outcomes (such as stating that 1/3 is bigger than 1/2 as a consequence of the fact that 3 is bigger than 2). This sort of componential processing in which fractions are understood as the juxtaposition of two whole numbers, rather than as numbers on their own, has been called Whole Number Bias (Ni & Zhou, Educational Psychologist, 2005).

In this work, we conduct a correlational study evaluating the effect of individual differences in inhibitory control on the early learning of fraction ordering. In a short class, we taught basic fraction concepts and comparison to third grade children ($N = 59$, mean age = 8.91 years, $SD = 0.29$), who had not yet received any formal instruction on the topic. They were then evaluated in their comprehension of the concepts and operation in two different questionnaires. Individual inhibitory capacities were assessed using a Numerical Stroop task (Besner & Coltheart, Neuropsychologia, 1979).

Results indicate the presence of a significant negative correlation, $\rho = -0.4$, between the facilitation index provided by the Stroop task (one of several possible measures stating how much the presence of irrelevant information can influence decisions) and performance in fraction ordering. Crucially, this correlation is not due to a general failure to attend or to understand the instructional material on the part of the children with poorer inhibitory capacities, because it appears even when controlling for the results of the questionnaire on fraction concepts. Other extraneous variables such as socioeconomic status or previous informal knowledge of fractions were not observed to affect performance in the fraction ordering questionnaire.

Our data support the role of executive control processes in aiding to learn operations like fraction comparison, mirroring previous research stating that children's succees with ordering fractions may be delayed by months with respect to conceptual understanding (Byrnes & Wasik, Developmental Psychology, 1991). We thus suggest that inhibitory control is not only relevant in the sense of correct behavior in the classroom, but also as an active component of the process leading children to grasp new mathematical procedures that conflict with previously known ones. Several researchers have proposed that at least some executive control processes can be strengthened by means of training (e.g. through videogames, see Dye, Green, & Bavelier, Current Directions in Psychological Science, 2009), so that further research should address the potentiality of such interventions in boosting children's progress in the learning of fractions and other difficult mathematical objects.

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