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Spontaneous focusing on numerosity in preschool as a predictor of mathematical skills and knowledge in the fifth grade

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ABSTRACT

Previous studies in a variety of countries have shown that there are substantial individual differences in children's spontaneous focusing on numerosity (SFON), and these differences are positively related to the development of early numerical skills in preschool and primary school. A total of 74 5-year-olds participated in a 7-year follow-up study, in which we explored whether SFON measured with very small numerosities at 5 years of age predicts mathematical skills and knowledge, math motivation, and reading in fifth grade at 11 years of age. Results show that preschool SFON is a unique predictor of arithmetic fluency and number line estimation but not of rational number knowledge, mathematical achievement, math motivation, or reading. These results hold even after taking into account age, IQ, working memory, digit naming, and cardinality skills. The results of the current study further the understanding of how preschool SFON tendency plays a role in the development of different formal mathematical skills over an extended period of time.

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Introduction

Children's early mathematical skills are important predictors of later mathematical achievement (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Jordan, Kaplan, Ramineni, & Locuniak, 2009). Among early number skills, verbal counting skills and visual digit naming are particularly important for the development of formal mathematical skills (Göbel, Watson, Lervåg, & Hulme, 2014). In addition, Hannula and Lehtinen (2005) demonstrated that children's spontaneous focusing on numerosity (SFON) contributes to later mathematical skills. However, the exact nature of how preschool SFON with very small numerosities, digit naming, and cardinality skills together contribute to the long-term development of different aspects of mathematics has not been examined previously. The current study aimed to explore the role of SFON in individual differences in performance on different components of fifth-grade mathematical skills and knowledge, including whole number estimation, arithmetic fluency, and rational number knowledge. An investigation of the specific aspects of mathematical skills and knowledge that are related to early SFON tendency should clarify the role that SFON tendency may play in supporting mathematical development. In addition, the predictive specificity of these early number skills was examined by exploring their relation to reading skills and math motivation.

Spontaneous focusing on numerosity

More than a decade ago, Hannula and Lehtinen (2005) showed that in a task where children were asked to feed a bird with different-colored glass berries, only some children paid attention to the actual number of berries that were given to the bird. Many other children seemed to pay attention only to the way in which the berries were lifted to the mouth of the bird or to the feeding process itself—for example, feeding the bird all the available berries. The authors' conclusion was that children vary in spontaneously paying attention to the numerical dimension of this situation. Further evidence demonstrated that this variation was not entirely explained by children's enumeration skills or other requisite skills needed for the activities, suggesting that these individual differences are a result of specific attentional processes. Based on this, SFON is defined as

> a process of spontaneously (i.e., in a self-initiated way not prompted by others) focusing attention on the aspect of the exact number of a set of items or incidents and using of this information in one's action. SFON tendency indicates the amount of a child's spontaneous practice in using exact enumeration in her or his natural surroundings.
>
> [Hannula, Lepola, & Lehtinen, 2010, p. 395]

More recently, different instruments developed to capture this attentional tendency have constantly shown substantial inter-individual differences in children's SFON tendency (Batchelor, Inglis, & Gilmore, 2015; Gray & Reeve, 2016; Hannula & Lehtinen, 2005; Hannula et al., 2010; Hannula, Räsänen, & Lehtinen, 2007; Hannula-Sormunen, Lehtinen, & Räsänen, 2015). This tendency is relatively stable across different task contexts within individuals (Bojorque, Torbeyns, Hannula-Sormunen, van Nijlen, & Verschaffel, 2017; Hannula & Lehtinen, 2005; Hannula-Sormunen et al., 2015) and across different tasks using action–responses such as feeding a bird, posting letters, stamping dinosaurs, selecting the right number of socks for different caterpillars, and finding a treasure hidden under similar hats arranged in a line forming a semicircle (Gray & Reeve, 2016; Hannula & Lehtinen, 2005; Hannula-Sormunen et al., 2015). In contrast, SFON tasks requiring verbal descriptions, such as time-unlimited picture description tasks, have shown less stability with other SFON measures (Batchelor et al., 2015; Rathé, Torbeyns, De Smedt, Hannula-Sormunen, & Verschaffel, 2017), although written picture description tasks with older children measuring spontaneous focusing on quantitative relations have been found to be relatively stable across time and task (McMullen, Hannula-Sormunen, & Lehtinen, 2017).