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Children's understanding of fraction and decimal symbols and the notation-specific relation to pre-algebra ability

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ABSTRACT

Fraction and decimal concepts are notoriously difficult for children to learn yet are a major component of elementary and middle school math curriculum and an important prerequisite for higher order mathematics (i.e., algebra). Thus, recently there has been a push to understand how children think about rational number magnitudes in order to understand how to promote rational number understanding. However, prior work investigating these questions has focused almost exclusively on fraction notation, overlooking the open questions of how children integrate rational number magnitudes presented in distinct notations (i.e., fractions, decimals, and whole numbers) and whether understanding of these distinct notations may independently contribute to pre-algebra ability. In the current study, we investigated rational number magnitude and arithmetic performance in both fraction and decimal notation in fourth- to seventh-grade children. We then explored how these measures of rational number ability predicted pre-algebra ability. Results reveal that children do represent the magnitudes of fractions and decimals as falling within a single numerical continuum and that, despite greater experience with fraction notation, children are more accurate when processing decimal notation than when processing fraction notation. Regression analyses revealed that both magnitude and arithmetic performance predicted pre-algebra ability, but magnitude understanding may be particularly unique and depend on notation. The

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educational implications of differences between children in the current study and previous work with adults are discussed.

Introduction

Rational number instruction is a major component of most elementary and middle school curricula (National Governors Association Center for Best Practices, 2010; National Mathematics Advisory Panel., 2008). However, despite the focus on teaching these concepts, children and adults still encounter significant difficulty in understanding rational numbers. Recently, educational and psychological research has paid particular attention to fraction understanding to identify exactly how it is that adults and children think about rational numbers in terms of both magnitude and arithmetic (e.g., DeWolf, Grounds, Bassok, & Holyoak, 2014; Hurst & Cordes, 2016; Iuculano and Butterworth, 2011; Lortie-Forgues, Tian, & Siegler, 2015; Meert, Gregoire, & Noel, 2010; Schneider & Siegler, 2010; Siegler, Thompson, & Schneider, 2011; Wang & Siegler, 2013) and has identified a link between rational number understanding and more advanced math learning, including algebra (Booth & Newton, 2012; Booth, Newton, & Twiss-Garrity, 2014; DeWolf, Bassok, & Holyoak, 2015b; Hurst & Cordes, 2017a, 2017b; Siegler et al., 2012). Surprisingly, however, much of this research has focused on how understanding of fraction notation specifically may contribute to algebra learning and ability, overlooking the fact that the same magnitudes can be represented using distinct notations (e.g., the magnitude of half can be written as 0.5 or 1/2) and that these notations are typically taught in different ways and at different grade levels. Thus, there remain open questions as to whether the demonstrated relation between rational number understanding and algebra may be notation dependent and whether this may change across educational stages.

In the current study, we aimed to characterize fourth- to seventh-grade children's processing of symbolic rational numbers across distinct notations and to clarify its relationship to other math domains, specifically pre-algebra ability. Critically, given that fraction instruction and decimal instruction typically begin in different grades, span several years, and are often taught separately (e.g., National Governors Association Center for Best Practices, 2010), it is possible that children learning these concepts may differentially rely on fraction or decimal notation across distinct contexts (e.g., DeWolf, Bassok, & Holyoak, 2015a; Iuculano and Butterworth, 2011; Rapp, Bassok, DeWolf, & Holyoak, 2015). As such, children might not immediately understand how to integrate decimal and fraction information (i.e., treat decimals and fractions as falling along distinct numerical continua), making some aspects of notation-dependent rational number learning more critical for advanced mathematical thinking than others. Thus, this age group was chosen to provide a window into fraction and decimal understanding in children who have recently learned and are currently learning these concepts.

In this study, we had two main goals: First, we aimed to shed light on children's processing of symbolic magnitude by examining their ability to compare rational number magnitudes presented in distinct notations (fraction, decimal, and whole number). Second, we aimed to clarify the relation between rational number understanding and pre-algebra ability in school-aged children in two ways: (a) by directly comparing the relative strength of rational number magnitude understanding and rational number arithmetic proficiency in predicting pre-algebra performance and (b) by looking at the relation to pre-algebra performance for both fraction and decimal notations in particular.

Symbolic magnitudes

Substantial research has investigated how children and adults process symbolic whole numbers (i.e., 1, 2, 3, etc.) using a variety of tasks. One task used to investigate magnitude understanding is the number comparison task, in which the participant is asked to rapidly choose which of two symbols represents the larger magnitude. Data from this task robustly reveal systematic responding based on