Journal of Experimental Child Psychology 154 (2017) 146–163

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Examining the relationship between rapid automatized naming and arithmetic fluency in Chinese kindergarten children

Jiaxin Cui [a,b], George K. Georgiou [c,*], Yiyun Zhang [d], Yixun Li [e], Hua Shu [a], Xinlin Zhou [a,b]

[a] *State Key Laboratory of Cognitive Neuroscience and Learning & IDG/McGovern School of Brain and Cognitive Sciences, Beijing Normal University, Beijing 100875, People's Republic of China*
[b] *Advanced Innovation Center for Future Education & Siegler Center for Innovative Learning, Beijing Normal University, Beijing 100875, China*
[c] *Department of Educational Psychology, University of Alberta, Edmonton, Alberta T6G 2G5, Canada*
[d] *School of Psychology, Liaoning Normal University, Dalian 116029, China*
[e] *School of Psychology, Beijing Normal University, Beijing 100875, People's Republic of China*

ARTICLE INFO

Article history:
Received 5 January 2016
Revised 1 September 2016
Available online 21 November 2016

Keywords:
Rapid automatized naming
Arithmetic fluency
Phonological processing
Speed of processing
Approximate number system acuity
Chinese

ABSTRACT

Rapid automatized naming (RAN) has been found to predict mathematics. However, the nature of their relationship remains unclear. Thus, the purpose of this study was twofold: (a) to examine how RAN (numeric and non-numeric) predicts a subdomain of mathematics (arithmetic fluency) and (b) to examine what processing skills may account for the RAN–arithmetic fluency relationship. A total of 160 third-year kindergarten Chinese children (83 boys and 77 girls, mean age = 5.11 years) were assessed on RAN (colors, objects, digits, and dice), nonverbal IQ, visual–verbal paired associate learning, phonological awareness, short-term memory, speed of processing, approximate number system acuity, and arithmetic fluency (addition and subtraction). The results indicated first that RAN was a significant correlate of arithmetic fluency and the correlations did not vary as a function of type of RAN or arithmetic fluency tasks. In addition, RAN continued to predict addition and subtraction fluency even after controlling for all other processing skills. Taken together, these findings challenge the existing theoretical accounts of the RAN–arithmetic fluency relationship and

* Corresponding author.
E-mail address: georgiou@ualberta.ca (G.K. Georgiou).

http://dx.doi.org/10.1016/j.jecp.2016.10.008

suggest that, similar to reading fluency, multiple processes underlie the RAN–arithmetic fluency relationship.

Introduction

It is indisputable that rapid automatized naming (RAN), defined as the ability to name as quickly as possible an array of highly familiar visual stimuli such as colors, objects, numbers, and letters, is a strong predictor of reading (e.g., de Jong, 2011; Georgiou, Aro, Liao, & Parrila, 2016; Landerl & Wimmer, 2008; Liao et al., 2015; Powell, Stainthorp, Stuart, Garwood, & Quinlan, 2007). However, more recently a number of studies have shown that RAN also predicts mathematics (e.g., Berg, 2008; Cowan & Powell, 2014; Georgiou, Tziraki, Manolitsis, & Fella, 2013; Koponen, Aunola, Ahonen, & Nurmi, 2007; Koponen, Salmi, Eklund, & Aro, 2013; Swanson, 2011) and distinguishes children with and without math disabilities (e.g., Landerl, Bevan, & Butterworth, 2004; Mazzocco & Grimm, 2013). Although several theoretical accounts have been proposed to explain the RAN–reading relationship (see Georgiou & Parrila, 2013, for a review), it remains unclear what cognitive processes underlie the relationship between RAN and mathematics. This is important in light of the diverse use of RAN tasks in mathematics research (e.g., as a measure of processing speed: Berg, 2008; as a measure of phonological processing: Swanson, 2004; as a language-related skill: Mazzocco & Myers, 2003). In this study, we aimed to examine the relationship between RAN and a subdomain of mathematics, arithmetic fluency, in an unselected group of Chinese kindergarten children.

The first studies examining the role of RAN in mathematics made their appearance during the early 2000s (e.g., Hecht, Torgesen, Wagner, & Rashotte, 2001; Mazzocco & Myers, 2003; Swanson & Sachse-Lee, 2001; Temple & Sherwood, 2002).[1] Since then, several studies have shown that RAN continues to predict mathematics (particularly arithmetic fluency) even after controlling for the effects of other known predictors of mathematics such as working memory (e.g., Swanson & Kim, 2007), executive functions (e.g., van der Sluis, de Jong, & van der Leij, 2004), counting (e.g., Koponen et al., 2007), and reading (e.g., Berg, 2008). However, previous studies have at least four limitations. First, only a few studies have examined the RAN–mathematics relationship using an unselected sample of kindergarten children (Georgiou et al., 2013; Koponen et al., 2013) and none has administered measures of RAN digits and quantities (measured in our study with dice). This allows us to test whether the relationship between RAN and mathematics is format specific (being higher when RAN is assessed with tasks that involve numbers). Second, most previous studies have examined whether RAN, among other processing skills, predicts mathematics and not what processes underlie the RAN–mathematics relationship. Third, the few studies that examined more closely the RAN–mathematics relationship (e.g., Georgiou et al., 2013; Koponen et al., 2013) have assessed only a limited set of cognitive processes (e.g., phonological awareness, phonological short-term memory) that may underlie the RAN–mathematics relationship. Finally, to our knowledge, no studies have examined the relationship between RAN and mathematics in Chinese. Given the well-documented linguistic and cultural differences between China and North America in mathematics learning (see below for a more detailed description of these differences), it is important to examine how RAN relates to mathematics in this population.

According to a popular view, RAN relates to mathematics because it taps the ability to access and retrieve phonological representations from long-term memory (De Smedt, Taylor, Archibald, & Ansari, 2010; Simmons & Singleton, 2008). If phonological representations for number words and number facts in long-term memory are weak and imprecise, then this will affect how quickly they can be retrieved from long-term memory, which in turn will impact math development. Geary (1993) further suggested that both representation and retrieval of phonological information from long-term memory

[1] We review here the literature on RAN and mathematics in general because there are only a few studies on RAN and arithmetic fluency alone and because the theoretical accounts of the RAN–mathematics relationship were not tied to arithmetic fluency.