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Different speed of processing levels in childhood and their contribution to early literacy and reading abilities

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ABSTRACT

Based on the effectiveness of speed of processing (SOP) skills, in particular rapid automatic naming, in kindergarten children to predict reading in first grade, the aim of the current study was to examine the connections between SOP skills and early literacy skills in kindergarten and their relationship to reading abilities in first grade. Ninety-six children were tested twice: first in kindergarten using speed of processing, early literacy, phonological awareness, language and rapid naming speed measures; and a year later in first grade, using speed of processing and different reading ability measures (decoding, reading comprehension, and fluency). The children were divided into three groups according to their performance on the speed of processing measures: slow, average, and fast. In kindergarten, the group with slow SOP exhibited the lowest scores on all the measures, while the groups with average and fast SOP performed better, with no significant difference between them. In first grade, speed of processing skills affected the different reading abilities in a dissimilar way, and the three groups showed different patterns of reading ability. SOP in kindergarten explained approximately 11% of the variance in reading in the 1st grade among the slow and average SOP groups. These findings have implications for early assessment and intervention.

Different Speed of processing levels in childhood and their contribution to early literacy and reading abilities

Reading is one of the most complex cognitive processes a person needs to learn. Understanding the cognitive factors that underlie reading is essential to identifying and preventing learning difficulties before they take root (Kirby, Desrochers, Roth, & Lai, 2008). Every cognitive task involves basic information processing stages that include perception, memory processes, and a output that usually ends with a decision or action made by the processor. Because of the limited amount of information that can be processed in a given amount of time, one of the most important skills is speed of processing (SOP) – the rate at which an individual performs cognitive processes. Every task that demands processing of different types of stimuli is considered to involve SOP. SOP can be measured by tasks ranging from a simple reaction time task to complex ones such as mathematical calculations and choice reaction times.

Speed of processing and naming

Research has shown that SOP predicts performance on various cognitive tasks (Kail & Ferrer, 2007). Higher SOP helps to increase capacity of working memory, enhance reasoning, and reach greater accuracy in solving mathematical problems (Fry & Hale, 1996; Kail, 2007; Kail & Hall, 1999). High SOP was found to be associated with higher intelligence (Bonifacci & Snowling, 2008; Sheppard & Vernon, 2008) and with different types of processing speed tasks, such as simple reaction time and visual search for numbers and symbols, which have been categorized as general speed of information processing tasks (Sheppard & Vernon, 2008). High SOP is also related to speed of short- and long-term memory processing and inspection time (Sheppard & Vernon, 2008). In addition, it has been reported that the harder and more complex the task, the stronger correlation is found between the performance on the task and IQ (Sheppard & Vernon, 2008). Therefore, it can be concluded that SOP is a skill which plays an essential role in different types of cognitive processing including our general ability (IQ).

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One of the most common tasks used to examine SOP in the reading and linguistic domain is Naming – the ability of labeling a stimulus (retrieving the word of a picture from memory). Rapid automatized naming task (RAN) is the ability to name continuously presented familiar symbols as fast as possible (usually 50 stimuli from the same semantic category such as numbers, colors, objects, or letters) (Koponen, Salmi, Eklund, & Aro, 2013). Naming has been considered to be one of many cognitive skills that underlie word recognition skill and is correlated with fluent reading in school-age children (Warmington & Hulme, 2012).

There is considerable debate over which cognitive skills are involved in the RAN task. Wagner and Torgesen (1987) assumed RAN represents phonological processing because it measures the rate at which children can access and retrieve phonological information stored in their long-term memory. Spring and Davis (1988) claimed it is a reading-specific skill that reflects the automaticity of reading. Bowers and Wolf (1993) and Bowers (1995) suggested that RAN reflects orthographic skills and the ability to connect them to their phonological representations, while Kail and Hall (1994) argued that RAN is a general SOP ability and therefore RAN and reading are connected to general SOP. In addition to the requirement of retrieving the verbal label of a symbol from long term memory, RAN also involves visual scanning processes and motor processes involved in articulation of the words (Powell, Stainthorp, Stuart, Garwood, & Quinlan, 2007).

Naming and reading

The association between RAN and reading skills is well established. Kail, Hall, and Caskey (1999) found it to be a significant predictor of reading skills. RAN of digits, letters and colors was related to reading accuracy, reading fluency, and reading comprehension among subjects at different reading levels, from typical to impaired readers (Kail & Hall, 1994; Spring & Davis, 1988; Wolf & Obregon, 1992; Young & Bowers, 1995). This finding has been replicated in several different languages, including German (Wimmer, 1993), Dutch (de Jong & van der Leij, 2003) and Italian (Di Filippo et al., 2006). Although the strong connection between naming and reading remains after controlling for different mediating variables such as IQ, short-term memory, articulation rate, letter knowledge and more, the strength of the connection varies depending on such factors as the type of naming test (the type of stimuli that the subject needs to name), the reading function being examined, and the age of the subjects (Georgiou, Parilla, Kirby, & Stephenson, 2008). Thus, to fully understand the link between these variables, it is important to measure general basic SOP, which is not based on linguistic skills, in addition to naming abilities. The current study will use these type of tests in order examine this connection.

Kail and Hall (1994) found that SOP, measured by a visual matching test which demands the subjects to cross out similar shapes (Woodcock & Johnson, 1989), significantly predicts RAN and that both are related to reading ability. When they added the variable of print exposure to the formula in a later study of 7–13 year olds (Kail, Hall, & Caskey, 1999), they found that naming speed was also connected to the global SOP score, but automaticity of reading and print exposure were associated directly with decoding ability. The authors concluded that SOP is linked both to naming and to reading skills, which have some common roots, and slow naming is more of a global difficulty and not reading-specific. In a study of the relationship between phonological processing, basic SOP, and naming skills in 7–10-year-old children, RAN deficits occurred without phonological deficits and RAN made a unique contribution to reading ability even after accounting for basic SOP (Powell, Stainthorp, Stuart, Garwood, & Quinlan, 2007). These authors concluded that among children who have learned to read, SOP is not the only factor accounting for the relationship between RAN performance and reading ability. Thus, the present study investigated basic SOP skills in addition to naming skills, which involve several additional abilities such as linguistic articulation and retrieval abilities which are not part of basic speed of processing tasks.

While these studies demonstrate the connection between reading skills, naming ability and SOP, the complexity of the variables involved in the RAN task calls for further study. Slow SOP was found to be a characteristic of poor and dyslexic readers, with a double deficit (Wolf & Bowers, 1999) whereby children with both naming speed and phonological deficits have greater difficulty reading. RAN has also been considered a measure of speed of the retrieval of the association between a visual word and its phonological representation from long-term memory (Warmington & Hulme, 2012), and therefore the more efficient this procedure is the better word recognition system the child develops. According to Warmington and Hulme (2012), RAN is strongly correlated with reading fluency and therefore children with low naming speed are children who exhibit dysfluent reading and usually have difficulties with reading.

Furthermore, in a recent longitudinal study by Koponen et al. (2013) RAN measured by naming of objects and colors at age 6 predicted reading fluency as well as calculation abilities in 2nd grade. The authors suggested that RAN is a measure of how fast an individual can map the verbal label from different types of visual stimuli, and therefore this ability is important not only for reading but also other areas such as mathematics.

Longitudinal research has shown that early literacy skills (such as vocabulary, listening comprehension, phonological processing) and numeracy skills (such as comparing numerical magnitudes, counting, number identification), together with basic cognitive skills (such as working memory, SOP and attention), are a firm base for the development of academic skills on entering school (Krajewski & Schneider, 2009; Purpura, Hume, Sims, & Lonigan, 2011). RAN in kindergarten children has been one of the most effective predictors of reading in first grade (Georgiou et al., 2008; Kirby, Georgiou, Martinussen, & Parrila, 2010), but we know that the RAN task involves many processes additional to SOP and not all young children know the letter names and therefore can't perform the letter naming task.

The current study

The question which arises is what is the contribution of basic SOP to predicting reading in first grade? Is there a basic skill such as SOP which underlies all the abilities in kindergarten including RAN, and is SOP an informative tool (which is easy to asses) which will be helpful in identifying children at risk for reading disabilities?

Therefore, the first aim of our study was to investigate the connections between SOP skills and early literacy skills in kindergarten, and their relationship to reading abilities in first grade. This question will take into account the known contribution of IQ and RAN in kindergarten to the prediction of reading abilities in first grade, and examine the specific contribution of SOP above these variables. Our second aim was to examine the associations between SOP skills in kindergarten and first grade and early literacy and reading abilities in children with different levels of SOP: slow, average, and fast. Based on the growing body of evidence suggesting that children with dyslexia have SOP impairments (Breznitz & Meyler, 2003; McGrath et al., 2011), we examined whether these three groups of children with different SOP exhibit different reading skills in first grade. Testing children before they have experienced formal teaching of reading may enhance our understanding of these still unclear associations.