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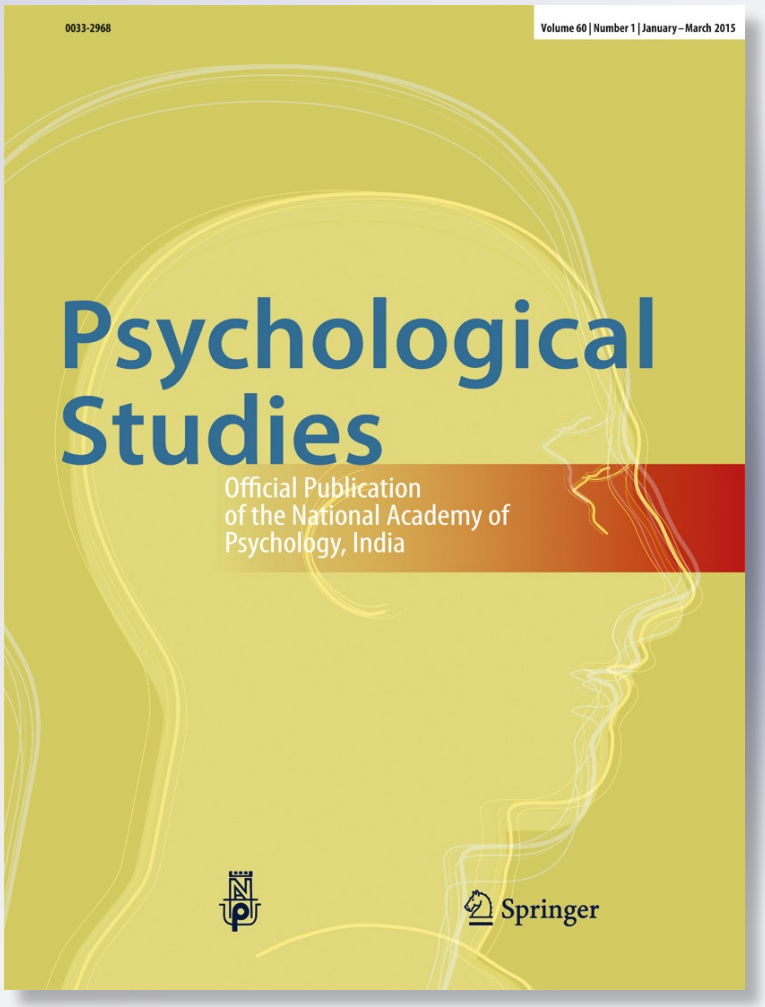

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REVIEW ARTICLE

Rapid Automatized Naming and Reading: A Review

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Abstract Most of the studies on naming speed have shown that rapid automatized naming (RAN) test to be a useful concurrent and future predictor of reading ability in children. Individuals who show poor performances on RAN tasks are likely to have difficulty in reading. According to the double deficit hypothesis (DDH) deficits in phonological awareness (PA) and RAN are the primary causative factors of reading disability (RD). The present review presents the origin of RAN test, its measures, its relationship with reading, phonological awareness, and general speed of processing in the light of available research.

Keywords Rapid automatized naming · Phonological awareness · Orthography and processing speed

Reading is a complex cognitive process which involves lower order perceptual, visual-auditory processing as well as higher order memory, inferential thinking, psycholinguistic skills that underlie decoding and comprehension of the written language. It has been regarded as a highly valued skill by society. But, about 5–12 % of school going children, despite having normal intelligence, conventional schooling, intact hearing and vision, adequate motivation and socio-cultural opportunities fail to acquire reading skill (Lagae 2008). Why do such children fail to learn to read? Poor phonological awareness has been recognized as one of the main reasons for reading disability. However, some children with good phonological awareness also show difficulty in learning to read. Later studies showed that deficit in rapid automatized reading (RAN) may also lead to reading disability (RD). RAN is the time (duration) individuals take for naming objects/pictures/colors/letters/digits as quickly as they can. It is also sometimes called by some other terms such as rapid naming, rapid serial naming, and serial naming etc. There are a few norm based as well as criterion based such tests currently used by researchers. RAN (Denckla and Rudel 1974), Rapid Alternate Stimulus (RAN-RAS) Wolf and Denckla (2005), comprehensive test of phonological processing (CTOPP), developed by Wagner et al. (1999), and Kaufman test of educational achievement (published by Pearson group in India) are some of the major tests in practice. These tests, however differ slightly in details and also sometimes in terms of theoretical views. However, a series of studies on RAN (Denckla and Rudel 1972, 1974, 1976) as a predictor of reading success initiated an entire area of investigation within the educational field.

The concept of RAN was first introduced by Geschwind and Fusillo in the year 1966 (Geschwind and Fusillo 1966). Denckla and Rudel (1972) examined color naming ability in five boys, aged 7.5–10.7, with unexpected reading failure. They found that the speed, with which names are retrieved, rather than the accuracy in color naming or the naming itself, differentiated poor readers from others. Later Denckla and Rudel developed and added three additional tests of RAN similar to color naming (digits, letter and objects) and found that latency was more predictive than errors with these new stimuli (Denckla and Rudel 1974). Work by Denckla and Rudel gave rise to a new line of questioning and thinking that initiated the entire field of educational (Denckla and Cutting 1999). RAN is now been firmly established to be a strong predictor of present and future reading development in both alphabetic (e.g. Cardoso-Martins and Pennington 2004; de Jong and van der Leij 1999; Kirby et al. 2003; Poulsen et al. 2012; Vaessen et al. 2010; Verhagen et al. 2010) and non alphabetic writing systems (e.g. Ho and Lai 2000; McBride-Chang et al. 2004; Pan et al. 2011). Several studies have shown significant association between RAN and reading

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accuracy (Neuhaus et al. 2001), RAN and reading comprehension (Georgiou et al. 2010; Neuhaus et al. 2001; Padakannaya et al. 2008), and also between RAN and reading speed (Wimmer 1993). RAN tasks appear to predict unique variance in reading other than those predicted by phonological awareness, letter knowledge and other well-established predictors of reading ability (Kirby et al. 2003). Overall strong findings on its reading-related predictive power has made RAN one of the most useful tools for predicting children at risk for reading difficulties (De Jong and Van der Leij 2003; Puolakanaho et al. 2007). Those children who performed low on RAN were significantly poor in spelling (Stainthrop et al. 2013). Further, Frijters et al. (2011) reported that RAN-reading relationship is stronger in poor than in typical readers.

However, scientists differ on various aspects of RAN testing. Some of the issues debated among the scientists are briefly mentioned here. One of them is related to the question whether RAN measures should be presented in a continuous format as it was originally developed or in a discrete format where each stimulus is presented individually. Another is related to whether RAN measures make a distinct and unique contribution in predicting reading ability that is separate from other cognitive or language predictors, such as phonological awareness and working memory. Some researchers (Bowers 1989; Wolf et al. 1986) advocate that the continuous versions are better and it makes RAN a strong predictor of reading. Proponents of this view suggest that the continuous format places more demands on executive functioning than the discrete formant of RAN (Denckla and Cutting 1999). They also found that the continuous version of RAN was more consistent in discriminating between good and poor readers among children (Grigorenko et al. 1997) and adults (Felton et al. 1990).

Several researchers argue that RAN makes a distinct contribution in predicting reading ability (McBride-Chang and Manis 1996; Wolf et al. 2000), whereas others claim that RAN is a test that measures a component of phonological processing (Vellutino et al. 1996; Wagner et al. 1993). The arguments that the RAN test measures a separate process from phonological processing comes from the fact that RAN consistently makes a unique contribution in predicting reading, and that poor readers can be sub-typed into those with RAN deficits only, phonological deficits only, and those who have deficits in both phonological processing and RAN (Denckla and Cutting 1999).

Components of RAN

In an task analysis of RAN, Wolf and Denckla (2005) reported several component processes that underlie rapid naming. They included: attention, feature detection, visual discrimination and pattern identification, integration of characters with stored orthographic representations and phonological representation, access to phonological labels, activation and integration of semantic information, and articulation. Each one of these is vital for success in RAN task. However, relative contribution of articulation time and pause time in RAN has been one of the major concerns in recent studies. Neuhaus et al. (2001a) defined pause time as "the sum of the length of pauses that are intervals between the correctly sequenced articulations" and articulation time as "the sum of all correctly articulated times that correspond to the displayed RAN stimuli". Several studies suggested that the pause time (rather than the articulate time) consistently differentiated children with and without dyslexia (e.g., Anderson et al. 1984; Aroujo et al. 2011; Neuhaus et al. 2001b). In particular, a longitudinal study by Cobbold et al. (2003) using letter naming and several cross-sectional studies on letter and digit naming (Clarke et al. 2005; Georgiou et al. 2006;) also supported the view that the pause time rather than the length of articulation time is a better predictor of reading. However, Neuhaus and Swank (2002) reported that pause time in letter naming and object-naming tasks were more related to reading in a large sample of first grade level children. Studies which examined the development of the RAN components suggests that pause time developmental changes are greater in absolute magnitude when compared with articulation time. However, conflicting results on articulation time component in some of the studies reported call for more research to unravel the question of specific roles these components play in reading.

Theoretically separation of RAN components has been considered to be important by many so as to understanding the development processes within RAN, what processes different RAN tasks share and what accounts for RAN's relationship with reading measures (Neuhaus et al. 2001a; Wolf et al. 2000). In terms of practice, intervention programs can be improved with more in-depth knowledge and understanding of RAN-specific information (e.g., Thaler et al. 2004).

Phonological Awareness, Orthography and RAN

Phonological processing refers to one's skills in using information about the phonology of language in processing written and oral language. Researchers have found three kinds of phonological processing skills that are positively correlated with reading (a) Phonological awareness, (b) Phonological memory and (c) Rate of access for phonological information. Phonological awareness (PA) is regarded as one of the major skills of phonological processing. PA refers to a child's ability to detect and manipulate the component sounds of one's language at the levels of different "grain sizes" (Ziegler and Goswami 2005). PA constitutes several tasks such as rhyme

detection, rhyme generation, combining/segmenting and adding syllable, deleting and substituting phonemes in words, and recognizing the position of a phoneme in a word. Thus, PA is also defined as "one's sensitivity to, or explicit awareness of, the phonological (sound) structure of words in one's language" (Torgesen et al. 1994).

According to the theory of 'Double Deficit Hypothesis' proposed by Bowers and Wolf (1993) children with reading difficulties can be characterized as those with phonological deficits only, those with naming deficits only, and those exhibiting deficits in both phonological and naming speed domains. According to this theory, individuals exhibiting both phonological and naming speed deficits have the most severe reading impairments (Wolf and Bowers 1999). Many researchers agree that the presence of deficits in phonological awareness and rapid serial naming can have severe negative consequences and may hamper development of reading. A study by McBride-Chang and Manis (1996) to test the existence of these deficits in a sample of 125 3rd and 4th grade children with and without dyslexia showed that while PA was a significant predictor of word reading in both groups, naming speed was found to be a significant predictor of word reading for children with dyslexia alone. In another study, Torgesen, et al. (1997) found that both naming speed and phonological awareness were significant predictors of word reading but the association between rapid naming and word reading was not significant at early stages of reading. A recent review of research on the applicability of the double-deficit hypothesis also suggests that the results available so far are still inconclusive (Vukovic and Siegel 2006).

Due to the fact that the phonological awareness partially mediates RAN-reading relationship it has been clubbed under phonological processing (e.g., Bowey et al. 2005; Manis et al. 1999) and has been associated with reading complexity in monolingual speakers of different languages (Bowers and Wolf 1993) such as German (Wimmer et al. 1999), English (Wagner et al. 1997), and Chinese (Ho and Lai 2000). Poulsen et al. (2012), supporting this showed that phonological processing mediated the link between RAN and reading in their study in Danish (shallow orthography). Further, the orthography of a particular language may influence phonological development. A cross linguistic study by Kubozono (1996) involving different orthographies suggested that speaker's knowledge of orthography plays a crucial role in determining the preferred manner of speech segmentation. Interestingly, consistency of a particular orthography also seems to have an impact on the reading problems associated with dyslexia. Children with dyslexia particularly in English experience problems with the accurate reading of long unfamiliar words and non words (Snowling and Griffiths 2003). Yet for children with dyslexia in transparent languages, it is not so much the accuracy, but the fluency of the reading that is affected. They read more slowly than normally developing readers. Studies in different languages like German, Finish, Italian, English and Chinese (Brizzolara et al. 2006; Holopainen et al. 2001; Jiménez González and Hernández-Valle 2000; Müller and Brady 2001; Tressoldi et al. 2001; Wimmer 1993; Wimmer and Mayringer 2001) support the idea that reading speed seems to be more informative in reading shallow orthographies (Tressoldi et al. 2001). Thus, although performance on phonological awareness tasks predict success in learning to read in most languages (Castles and Coltheart 2004), RAN becomes important in languages with transparent orthography.

Some researchers argue that RAN tasks mainly assess the rate of access to and retrieval of stored phonological information from long-term memory and thus should be a part of phonological processing construct along with phonological awareness and phonological memory (Torgesen et al. 1994; Wagner and Torgesen 1987). On the other hand, Wolf et al. (2000) argue that the variance in RAN associated with reading would be mediated through orthographic processing rather than phonological processing. Georgiou et al. (2008) also suggest that orthographic knowledge seems to mediate RAN's role in reading fluency rather than phonological processing or speed of processing. They emphasized on the temporal variation or timing of the presentation of letters. Manis et al. (1999) emphasizing the role of orthographic processing proposed that RAN task's critical property, the relationship between the symbol and its name, is arbitrary, i.e. if reading tasks consists of more arbitrary orthography-to-phonology mappings (reading exception words versus reading regular words), then the RAN-reading relationship should be stronger. Others argued that RAN and reading reflects general cognitive processing speed (Klail and Hall 1994; Kail et al. 1999).

It is argued that the alphanumeric RAN pause time reflects both the speed of access to phonological information in long-term memory and the ease of building up high-quality orthographic representation that facilitate fluent reading. But, as the degree of association with phonological and/or orthographic processing changes across time, in the earlier years RAN pause time is highly correlated with phonological processing whereas in later grades it is highly correlated with orthographic processing. Strong relationship between RAN pause and phonological awareness at the early stages of reading development could mean that cognitive processes rely on the quality of phonological representations (e.g., Georgiou et al. 2008; Perfetti and Hart 2002). Likewise, poor representations of letters will result in the reduced quality of orthographic representations leading to slow and inaccurate reading (Bowers and Wolf 1993). Georgiou et al. (2008) reported that RAN pause time was significantly related to the orthographic knowledge and reading fluency across age groups. It has also been found that RAN is more correlated with irregular word reading as opposed to word decoding, which is consistent with other findings mentioned above.

Bowers' view of orthographic-processing account (Bowers 2001) proposes that sight word reading is affected by naming mainly through its association with a baseline for speed of visual letter string identification upon which orthographic knowledge has added effects. However, Georgiou et al. (2009) suggest that it is important to understand the differentiation between the levels of orthographic processing (lexical vs. sub-lexical) and the types of data (accuracy vs. response time) in order to understand the RAN-reading relationship. They showed that RAN pause time is more strongly correlated with sub-lexical response time than for verbal accuracy data. Several other studies (Bowers et al. 1999; Manis et al. 1999; Sunseth and Bowers 2002) also have shown that children with RAN deficit perform significantly poorer than controls on measures of sub-lexical orthographic processing. However, some other studies (e.g., Bowey and Miller 2007; Cunningham et al. 2002) do not support this. The relationship between RAN and orthographic processing thus needs further investigation for a clear understanding the relationship between them.

Georgiou et al. (2006) also suggested that the characteristics of the language's orthography might have effect on reading ability. A study by Wimmer (1993) on German children with dyslexia provided evidence that in transparent orthographies individual differences on phonological awareness may become less important in explaining reading ability, whereas differences in rapid naming ability become more important.

RAN in Later Stages of Reading Development

The processes responsible for the association between the RAN and reading vary across time (Georgiou et al. 2009). Age-related changes in global retrieval speed seem to change processing speed on a range of perceptual and cognitive tasks (Georgiou et al. 2008). In a longitudinal study by Kirby et al. (2003) on RAN-reading in children from Kindergarten to Grade 5found that there was an increase in the relative involvement of RAN in word reading and the same has been reported by other similar studies (e.g., Landerl and Wimmer 2008; Van den Bos et al. 2002). The fact that RAN was found to have strong influence on reading in first and second grades and diminishing influence from third to fifth grades in some other studies (e.g. Georgiou et al. 2008b; Roman et al. 2009; Torgesen et al. 1997) demands more empirical work before reaching a strong conclusion on this issue (Georgiou et al. 2009).

Bowey et al. (2005) hypothesized that in the initial stage of the reading development both letter knowledge and phonological-processing ability mediate the influence of RAN on reading, while in the later stages it is mainly phonological processing ability that mediates this. They did not examine the possibility of orthographic processing mediating this effect in later stages. Cirino et al. (2005) suggested that the relative contribution of RAN and phonological awareness on reading depends upon the nature of the reading task. While the measures of phonological awareness are good predictors of reading performance on measures of untimed decoding of words and non-words, RAN measures are good predictors of time taken for decoding of words and non-words.

Critical Evaluation

The above discussion makes it amply clear the importance of RAN in reading. However, the studies reviewed do not allow us to draw strong conclusions due to several reasons. Firstly, limitations in study designs and methods of data analysis of earlier studies may have resulted in conflicting results on the issue of pause and articulation times. The time-consuming analysis, small size sample, problematic software unable to correctly identify articulations or extraneous sounds may have led to variations in the outcome (Neuhaus et al. 2001a; Georgiou et al. 2006, 2008a, 2009). Also some studies (Georgiou et al. 2008b, 2009) were restricted on the developmental span studied and population examined. Results of the longitudinal designs seem to make a compromise in the final sample size.

Secondly, the use of different version of RAN tasks to measure pause and articulation components may partly account for the variability in the results (Compton et al. 2002). Georgiou et al. (2006) argued that although alphanumeric categories of RAN tasks (i.e., letter naming and digit naming) have been well established as a significant predictor of reading, to assess naming ability of young children, preference should be given to gain more information about the components of color naming and object naming. The time of measurement point of RAN is important and the studies should focus on the time period appropriate RAN tasks while studying the reading development. It is also important to understand the distinction between lexical and sub-lexical orthographic processing as recent researches have suggested a differential relationship between RAN and different aspects of orthographic processing (Bowers 2001; Parrila and Georgiou 2006; Powell et al. 2008).

Certain clinical implications are drawn from the research work of Wolf et al. (Wolf et al. 2000) for diagnosis and educational practices. The most important implication of the double-deficit hypothesis is to incorporate naming-speed measures into kindergarten and first- grade level screening batteries, which aid in the early identification processes. Researches recommend that phonological awareness, rapid naming and letter knowledge are the best predictors of reading acquisition (e.g. Bishop 2003; Catts 1996; League and Bishop 2004) and all must be part of any good assessment and remediation battery.

More recently, Norton and Wolf (2012) have suggested that RAN may be construed as automaticity in all the subcomponent processes involved in rapid naming and such a multicomponential approach will be most effective in understanding and remediation of developmental dyslexia.

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