Verbal and Non-verbal Measures of Rapid Automatized Processing - Implications for Reading

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Abstract

In the past few decades, Rapid Automatized Naming (RAN) has evolved as an efficient clinical tool to assess rapid processing and predict later reading abilities in young children. Over the years, several variants of the task came into existence such as inclusion of variety of stimuli, varying picture size, different response modalities etc. However, very few have addressed the influence of response modality and its relation with reading. This study aimed to compare rapid processing skills in typical children in verbal and nonverbal modalities and its relation with their reading abilities. Thirty typically developing children in the age range of 5-7 years participated in the study. Picture arrays of five common nouns served as the stimuli. Task comprised of picture naming and picture pointing. The results revealed that there was no significant difference in the processing of nouns between the two modalities. In addition, rapid processing in both verbal and non-verbal modalities was found to have a significant positive correlation with reading. Overall, the results point to the utility of non-verbal task as a measure of rapid processing and to predict later reading skills in children with limited verbal abilities.

Background

Reading is a complex cognitive process encompassing several linguistic factors and other lower (perceptual, visual-auditory) and higher order (memory, inferential thinking, psycholinguistic) skills. These factors are crucial to decode and comprehend written language (Siddaiah & Padakannaya, 2015). Over the last few decades, intense research in the field of reading and associated cognitive-linguistic processes has led to substantial increase in our understanding of the same. It must be noted that it is not just the multitude of processes involved in reading but also the rapid integration of vast neural circuitry that defines an efficient reader. In other words, both accuracy and speed are essential components of reading. As reading abilities develop, each of the lower and higher order functions work with both accuracy and speed until a reader develops automaticity and reads effortlessly (Norton & Wolf, 2012).

Basic phonological abilities are considered to be strong predictors of later reading achievements (Bradley & Bryant, 1985; Castles & Coltheart, 2004; Fox & Routh, 1976; Liberman, Shankweiler & Liberman, 1989; Mann & Liberman, 1984; Stanovich, Cunningham & Feeman, 1984; Wagner & Torgeson, 1987; Yopp, 1988). A few researchers consider Rapid Automatized Naming (RAN) as a basic phonological skill (Felton & Brown, 1990; Shaywitz, 2003; Wagner, Torgesen, & Rashotte, 1999), while few others view it as an index of processing speed (Ackerman, Holloway, Youngdahl, & Dykman, 2001; Hammill, Mather, Allen, & Roberts, 2003). RAN is defined as the ability to name a sequence of familiar visual stimuli both rapidly and accurately. RAN was first conceptualized by Geshwind and Fusillo (1966). Later, Denckla and Rudel (1976a; 1976b) developed the basic test to assess rapid naming skills which consisted primarily of four categories (letters, numbers, colors and objects). The plethora of studies available suggests that RAN is a strong predictor of later reading achievements of a child.

Several theories have been postulated to resolve the RAN-reading relationship. According to the double deficit theory of reading disability (Wolf, 1996), RAN and phonological processing involve different cognitive processes. Several literature reports corroborate with this theory and indicate deficits in both RAN and phonological processing abilities in individuals with reading disability (Bowers, 1996; 2001; Wolf, 2001; Wolf & Bowers, 1999). In contrast to the double deficit theory, RAN is con-

sidered as a phonological process governing reading speed (Bowers & Wolf, 1993; Catts, Gillispie, Leonard, Kail, & Miller, 2002; Torgesen, Wagner, & Rashotte, 1994). This group of researchers suggested that both RAN and reading demand rapid execution of constituent processes and thus can be considered as measures of the global speed of processing. Roberts and Mather (1997) proposed RAN as an appraisal of orthographic processing, while Nicolson and Fawcett (2000) attributed the deficits observed in RAN to impaired temporal processing owing to underlying cerebellar dysfunction. The recent view put forth by Shaywitz (2003) explained rapid naming as a measure of phonological access. It is also suggested that RAN is related to stages of brain development (Denckla, 1972), myelin deposition during developmental period and advances in language abilities (Dougherty, Ben-Shachar, Deutsch, Hernandez, & Fox, 2007).

Research in the last few decades have witnessed intensive research on RAN-reading relation, both in typically developing children (Georgiou, Parilla, & Kirby, 2006, 2009; Siddaiah, Saldanha, Venkatesh, Ramachandra, & Padakannaya, 2014; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997) and children with various developmental disorders (Aroujo, Inacio, Francisco, Faisca, Peterson, & Reis, 2011; Kirby, Parrila, & Pfieffer, 2003; Lahey & Edwards, 1996; Loss, Esserman, & Pivon, 2010; Wiig, Semel, & Nystrom, 1982; Wolf, Bowers, & Biddle, 2000; Wolf, Goldberg, O'Rourke, Gidney, Lovett, Cirino, & Morris, 2002; Zaretsky, Velleman, & Curro, 2010). While few of the researchers opine that RAN and reading abilities share a developmental relationship (Bowers et al., 1993; Catts et al., 2002; Torgesen, 1999; Wolf et al., 1999), few others consider this relation to recede with increase in age (Norton et al., 2012; Wolf, 2001). Nevertheless, RAN has proved to be a sensitive measure to predict later reading skills in both typically developing children and children with various developmental disorders (Siddaiah et al., 2015).

Subsequent research exploring RAN-reading relationship made modifications in terms of type of stimulus (alphanumeric versus non-alphanumeric), format of RAN task (serial versus discrete), number of items or set size, mode of response (pantomime gestures, cancellation task, Yes/No) and outcome measure (accuracy based and fluency based). Mode of assessment has often been a challenge when assessing children with developmental disorders. The cancellation and Yes/No task did not correlate with reading abilities as strongly as the traditional RAN (Georgiou, Parrila, Cui, & Papadopoulos, 2013). Katz, Curtiss and Tallal (1992) used pantomime gestures as the non-verbal task and found that similar to the verbal RAN, non-verbal RAN also helps to differentiate between typically developing and language impaired children. Further RAN-verbal and reading had significant correlation for 6-8 years old typically developing children and for 8 year old language impaired children. However, pantomime gestures require relatively complex processing and hence, may not be an appropriate mode of response for younger children. Further, a shift in word class is also involved as target pictures were nouns and the expected responses (gesture) were the corresponding verb forms. These limitations pose a constraint for direct comparison of performance on RAN tasks in two modalities. Biddappa, Seth and Manjula (2016) conducted a preliminary investigation to assess the rapid processing of nouns and verbs in verbal and non-verbal modalities. They used the traditional RAN task for the verbal measure and pointing as the non-verbal mode of assessment. Their findings revealed no significant difference in the rapid processing of nouns in the two modalities whereas differences were observed for verbs. It must be noted that various areas of frontal, temporal and parietal cortex are involved in both naming and pointing tasks (Baldo, Arévalo, Patterson, & Dronkers, 2013; DeLeon, Gottesman, Kleinman, Newhart, Davis, Heidler-Gary, Lee, & Hillis, 2007; De Langavant, Remy, Trinkler, McIntyre, Dupoux, Berthoz, & Bachoud-Lévi, 2011; Astafiev, Shulman, Stanley, Snyder, Van Essen, & Corbetta, 2003). Given the well established relationship between rapid automatized naming and later reading skills and the similarities in the rapid processing abilities in both verbal and nonverbal modalities, it would be interesting to investigate the relationship between rapid processing in the non verbal modality and reading. Hence, the present study was taken up with the aim of utilizing a non-verbal protocol to assess rapid automatized processing of nouns and investigate its relation with reading in typically developing children. In addition, the present study also made an attempt to replicate the earlier investigations exploring rapid automatized processing of nouns in verbal modality and comparing it with the processing in non-verbal modality for the same set of participants.

Materials and Method

Participants

30 typically developing children in the age range of 5-7 years participated in the study. This included 15 children from Upper Kindergarten (UKG) (Mean age: 5;4 years) and 15 children from Grade I (Mean age: 6;4 years). All the participants spoke Kannada (a Dravidian language spoken in the state of Karnataka, South India) as their native language and resided in an urban environment of Kannada and English. The participants were recruited randomly from schools with English as the medium of instruction and which followed similar teaching methods. The presence of speech, lan-

guage, and hearing deficits were ruled out in all the participants using WHO Ten Questions Disability Screening Checklist (cited in Singhi, Kumar, Malhi, & Kumar, 2007). All participants belonged to middle socio-economic status as assessed by the revised NIMH Socio Economic Status Scale (Venkatesan, 2011). An informed consent was obtained from the caregivers of all participants. The research methodology adhered to the ethical guidelines prescribed by the Ethical Committee of the Institution.

Stimuli

Twenty common nouns were listed by the investigator, which were later given to ten undergraduate students of Speech and Hearing for rating on a three-point scale for familiarity as familiar, less familiar and not familiar with reference to typically developing children in the age range of 5-7 years. The five most common nouns based on the rating were chosen as the final set of stimuli, while the next four were included for the practice trials. These items were designed as colored line drawings on a computer by a graphic designer. The colored line drawings were given to five undergraduate students to rate for ambiguity on a 3 point rating scale as less ambiguous, ambiguous or most ambiguous. Based on the ratings, the items were modified till a rating of 'least ambiguous' is obtained for all the items by the same raters. Therefore, the final set of stimuli consisted of colored line drawings of five most common nouns (cat, chair, house, pen & tree) arranged in an array of 50 items (5 rows×10 columns). The items were repeated 10 times each and distributed on a random basis in the array. The entire array was printed on an A3 size sheet for good visibility and presented to the participants.

To assess the reading skills of children, a wordlist with 20 common words in English selected from the reading subsection of the 'Dyslexia Assessment Profile for Indian Children' (Kuppuraj & Shanbal, 2009) and English textbooks of UKG and Grade I was used.

Procedure

All the participants were seated in a quiet environment with adequate lighting and were assessed individually. The entire assessment was video recorded using a Sony Video Recorder. All the participants had to perform three tasks: RAN verbal (naming), RAN non-verbal (pointing) and reading.

A familiarity check was carried out to ensure that the participants were familiar with the stimuli used as test items. They were instructed to name each of the five test items presented as picture cards. The participants were then explained about the RAN task (verbal & non-verbal), followed by practice trials. The practice trial was carried out using an array of 12 items (3 rows×4

columns), which were different from the test items. The participants were instructed in English and in instances of uncertainty about the procedure instructions were repeated in their native language (Kannada) for better understanding.

Instructions and scoring

RAN verbal: In the RAN verbal task, each child was presented with the printed picture array and instructed to name (in English) the items serially as fast and as accurately as possible. The total duration to name all the 50 items in the array was noted.

RAN non-verbal: In the RAN non-verbal task, the participants were asked to point to all occurrences of the indicated target item in the complete array as quickly and as accurately as possible in a serial manner. This was carried out for each of the five target items. The video recorded samples were used to calculate the time taken to point to each of the items. The time taken to point to the five target items were added to obtain the total time taken for each participant.

Reading: In the reading task, children were asked to read the words in the given list. Each participant was instructed to read all the words as fast and as accurately as possible. The time taken to read all the words was noted.

Results

The present study aimed to investigate the rapid automatized processing of nouns in two modalities (verbal and non-verbal) and its correlation with reading skills in typically developing children. The total duration to perform each of the tasks (RAN verbal, RAN non-verbal & reading) was noted individually. The mean duration and standard deviation for rapid processing of nouns in two modalities (verbal and non-verbal) and reading for all participants are given in Table 1.

Table 1: Mean duration (in sec) and Standard Deviation (S.D.) for RAN verbal, RAN non-verbal and Reading tasks

Parameter	U.K.G		Grade I	
	Mean	S.D.	Mean	S.D.
RAN verbal	59.00	10.92	54.86	6.46
RAN non-verbal	55.40	11.50	49.66	9.20
Reading	47.06	13.72	35.93	7.67

The mean duration for processing nouns was found to be different in the two modalities as shown
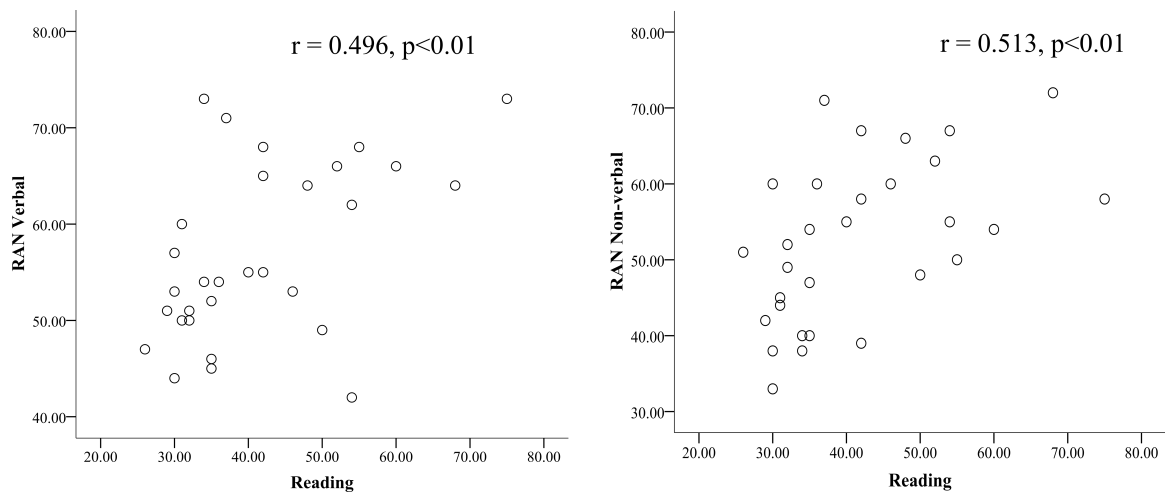
Figure 1: Scatter plot depicting the correlation of Reading with (a) RAN Verbal and (b) RAN Non-verbal.

in Table 1. The mean duration for the non-verbal task i.e., pointing was found to be lesser when compared to the verbal task of naming. It was found that Grade 1 participants performed better than participants from U.K.G. on all the three tasks of naming, pointing and reading.

To verify these findings, the data was subjected to analysis by suitable statistical tools using SPSS (version 21). The data was analyzed for normality using Shapiro-Wilk's test of normality which indicated a normal distribution pattern ($p > 0.05$). A 2 × 2 model of repeated measures ANOVA for modality was carried out with grade as the between subject factor. The results revealed no significant effect of modality ($F(1,28) = 3.789$, $p > 0.05$, partial $\eta^2 = 0.122$) and grade ($F(1,28) = 3.194$, $p > 0.05$, partial $\eta^2 = 0.102$). Further the interaction between modality and grade was also found to be statistically insignificant ($F(1,28) = 0.128$, $p > 0.05$, partial $\eta^2 = 0.005$).

The study also aimed to understand the correlation between reading and rapid processing in the two modalities respectively. As there was no significant grade effect, correlation analysis was performed on the combined data for grade. Pearson product-moment correlation indicated a significant positive correlation between rapid processing of nouns and reading in both verbal ($r = 0.496$, $p<0.01$) and non-verbal ($r = 0.513$, $p <0.01$) modalities as depicted in Figure 1.

Discussion

The present study investigated the rapid processing of nouns in both verbal and non-verbal modalities and its correlation with reading. The findings suggest no statistically significant difference in the rapid processing between the two grades. These findings are in consensus with the earlier study by Biddappa et al. (2016). However, it may be reiterated that the findings should be generalized with caution.

In addition to the grade, there were no significant effects of modality on performance of rapid processing tasks. This finding reflects similarities in verbal and nonverbal processing supporting the findings of our earlier investigation (Biddappa et al., 2016). Similar processing of nouns in the two modalities could be attributed to the automatization of noun class of words. Nouns are reported to be acquired in the early years of language acquisition (Gentner, 1982; Golinkoff & Hirsh-Pasek, 2008). Furthermore, researchers agree to the fact that nouns are usually predominant in both receptive and expressive vocabularies of young children (Bornstein et al., 2004; Umek, Fekonja-Peklaj, & Podlesek, 2013). It can be speculated that early acquisition and extensive usage of nouns during the developmental years is reflected as automatic processing with no significant differences observed between the two modalities. These findings corroborate with the findings of Katz et al. (1982) who suggested that both verbal and manual RAN measures share lexical representations, memory and perceptuomotor processes. Therefore, it is plausible that the sharing of these processes in the two modalities could have led to no significant differences in the two modalities.

The study also investigated the relationship between rapid processing of nouns in two modalities and reading. A significant positive correlation was found between rapid processing of nouns in the two modalities and reading. Earlier reports in the literature have supported the positive correlation between RAN and reading (Georgiou, Parrila, Cui, & Papadopoulos, 2013; Allor, 2002; Cutting & Denckla, 2001; Wolf & Bowers, 1999). RAN and reading are reported to share a series of common processes including eye saccades, working memory,

connection of orthographic and phonological representations, serial processing and active production of specific names (Norton & Wolf, 2012; Georgiou et al., 2013).

In addition to the traditional RAN-reading relationship, the study unveiled an interesting finding i.e., a significant positive correlation of rapid processing of nouns in the non-verbal modality with reading. The absence of any significant difference for rapid processing in the two modalities and a positive correlation of each of the modalities with reading suggest the prospects of pointing as a non-verbal mode of assessment of rapid processing skills. It can be assumed that the non-verbal mode of assessment also holds the potential to predict later reading achievements similar to verbal mode of assessment. This may have specific implications in assessment of children with limited verbal skills.

Conclusions

The study adds to the existing literature and enhances our understanding on the significance of rapid processing skills in young, typically developing children and its role in reading abilities. Similar processing in both verbal and non-verbal modalities serve as the behavioral evidence on the commonalities of verbal and non-verbal processing in addition to the existing neuroanatomical correlates and processing mechanisms. The correlation of non-verbal mode of assessment with reading offers a new perspective to assess rapid processing and predict reading skills in children with limited verbal skills in whom administration of traditional RAN tasks poses a challenge. However, the results should be generalized with caution and future investigations of rapid processing skills through non-verbal modalities and its correlation with reading in children with different developmental disorders may offer greater insights in this regard.

Acknowledgments

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