

# Paper1

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16  
1 2003). RAN is defined as the ability to name a sequence of familiar visual stimuli both rapidly  
2 and accurately. RAN was first conceptualized by Geshwind and Fusillo (1966). Later, Denckla  
3 and Rudel (1976a; 1976b) developed the basic test to assess rapid naming skills which consisted  
4 primarily of four categories (letters, numbers, colors and objects). The plethora of studies  
15  
5 available suggests that RAN is a strong predictor of later reading achievements of a child.

6  
7 Several theories have been postulated to resolve the RAN-reading relationship.  
42  
40  
8 According to the double deficit theory of reading disability (Wolf, 1996), RAN and phonological  
9 processing involve different cognitive processes. Several literature reports corroborate with this  
10 theory and indicate deficits in both RAN and phonological processing abilities in individuals  
39  
11 with reading disability (Bowers, 1996; 2001; Wolf, 2001; Wolf & Bowers, 1999). In contrast to  
38  
12 the double deficit theory, RAN is considered as a phonological process governing reading speed  
29  
13 (Bowers & Wolf, 1993; Catts, Gillispie, Leonard, Kail, & Miller, 2002; Torgesen, Wagner, &  
14 Rashotte, 1994). This group of researchers suggested that both RAN and reading demand rapid  
15 execution of constituent processes and thus can be considered as measures of the global speed of  
16 processing. Roberts and Mather (1997) proposed RAN as an appraisal of orthographic  
17 processing, while Nicolson and Fawcett (2000) attributed the deficits observed in RAN to  
18 impaired temporal processing owing to underlying cerebellar dysfunction. The recent view put  
2  
19 forth by Shaywitz (2003) explained rapid naming as a measure of phonological access. It is also  
20 suggested that RAN is related to stages of brain development (Denckla, 1972), myelin deposition  
21 during developmental period and advances in language abilities (Dougherty, Ben-Shachar,  
22 Deutsch, Hernandez, & Fox, 2007).

23

1           Research in the last few decades have witnessed intensive research on RAN-reading  
2 relation, both in typically developing children (Georgiou, Parilla, & Kirby, 2006, 2009; Siddaiah,  
3 Saldanha, Venkatesh, Ramachandra, & Padakannaya, 2014; Torgesen, Wanger, Rashotte,  
4 Burgess, & Hecht, 1997) and children with various developmental disorders (Aroujo, Inacio,  
5 Francisco, Faisca, Peterson, & Reis, 2011; Kirby, Parrila, & Pfeiffer, 2003; Lahey & Edwards,  
6 1996; Loss, Esserman, & Pivon, 2010; Wiig, Semel, & Nystrom, 1982; Wolf, Bowers, & Biddle,  
7 2000; Wolf, Goldberg, O'Rourke, Gidney, Lovett, Cirino, & Morris, 2002; Zaretsky, Velleman,  
8 & Curro, 2010). While few of the researchers opine that RAN and reading abilities share a  
9 developmental relationship (Bowers et al., 1993; Catts et al., 2002; Torgesen, 1999; Wolf et al.,  
10 1999), few others consider this relation to recede with increase in age (Norton et al., 2012; Wolf,  
11 2001). Nevertheless, RAN has proved to be a sensitive measure to predict later reading skills in  
12 both typically developing children and children with various developmental disorders (Siddaiah  
13 et al., 2015).

14  
15           Subsequent research exploring RAN-reading relationship made modifications in terms of  
16 type of stimulus (alphanumeric versus non-alphanumeric), format of RAN task (serial versus  
17 discrete), number of items or set size, mode of response (pantomime gestures, cancellation task,  
18 Yes/No) and outcome measure (accuracy based and fluency based). Mode of assessment has  
19 often been a challenge when assessing children with developmental disorders. The cancellation  
20 and Yes/No task did not correlate with reading abilities as strongly as the traditional RAN  
21 (Georgiou, Parrila, Cui, & Papadopoulos, 2013). Katz, Curtiss and Tallal (1992) used pantomime  
22 gestures as the non-verbal task and found that similar to the verbal RAN, non-verbal RAN also  
23 helps to differentiate between typically developing and language impaired children. Further

1 RAN-verbal and reading had significant correlation for 6-8 years <sup>37</sup> old typically developing  
2 children and for 8 year old language impaired children. However, pantomime gestures require  
3 relatively complex processing and hence, may not be an appropriate mode of response for  
4 younger children. Further, a shift in word class is also involved as target pictures were nouns and  
5 the expected responses (gesture) were the corresponding verb forms. These limitations pose a  
6 constraint for direct comparison of performance on RAN tasks in two modalities. Biddappa, Seth  
7 and Manjula (2016) conducted a preliminary investigation to assess the rapid processing of  
8 nouns and verbs in verbal and non-verbal modalities. They used the traditional RAN task for the  
9 verbal measure and pointing as the non-verbal mode of assessment. Their findings <sup>5</sup> revealed no  
10 significant difference in the rapid processing of nouns in the two modalities whereas differences  
11 were observed for verbs. It must be noted that various areas of frontal, temporal and parietal  
12 cortex are involved in both naming and pointing tasks (Baldo, Arévalo, Patterson, & Dronkers,  
13 <sup>22</sup> 2013; DeLeon, Gottesman, Kleinman, Newhart, Davis, Heidler-Gary, Lee, & Hillis, 2007; <sup>21</sup> De  
14 Langavant, Remy, Trinkler, McIntyre, Dupoux, Berthoz, & Bachoud-Lévi, 2011; <sup>36</sup> Astafiev,  
15 <sup>20</sup> Shulman, Stanley, Snyder, Van Essen, & Corbetta, 2003). Given the well established relationship  
16 between rapid automatized naming and later reading skills and the similarities in the rapid  
17 processing abilities in both verbal and nonverbal modalities, <sup>5</sup> it would be interesting to investigate  
18 the relationship between rapid processing in the non verbal modality and reading. <sup>1</sup> Hence, the  
19 present study was taken up with the aim of utilizing a non-verbal protocol to assess rapid  
20 automatized processing of nouns and investigate its relation with reading <sup>1</sup> in typically developing  
21 children.

22

23

## 1 **Materials and Method**

2

3 **Participants:** 30 typically developing children in the age range of 5 to 7 years participated in the  
4 study. This included 15 children from Upper Kindergarten (UKG) (Mean age: 5;4 years) and 15  
5 children from Grade I (Mean age: 6;4 years). All the participants spoke Kannada (a Dravidian  
6 language spoken in the state of Karnataka, South India) as their native language and resided in an  
7 urban environment of Kannada and English. The participants were recruited randomly from  
8 schools with English as the medium of instruction and which followed similar teaching methods.  
9 The presence speech, language, and hearing deficits were ruled out in all the participants using  
10 WHO Ten Questions Disability Screening Checklist (cited in Singhi, Kumar, Malhi, & Kumar,  
11 2007). All participants belonged to middle socio-economic status as assessed by the revised  
12 NIMH Socio Economic Status Scale (Venkatesan, 2011). An informed consent was obtained  
13 from the caregivers of all participants. The research methodology adhered to the ethical  
14 guidelines prescribed by the Ethical Committee of the Institution.

15

16 **Stimuli:** Twenty common nouns were listed by the investigator, which were later given to ten  
17 undergraduate students of Speech and Hearing for rating on a three-point scale for familiarity as  
18 familiar, less familiar and not familiar. The five most common nouns based on the rating were  
19 chosen as the final set of stimuli, while the next four were included for the practice trials. These  
20 items were designed as colored line drawings on a computer by a graphic designer. The colored  
21 line drawings were given to five undergraduate students to rate for ambiguity on a 3 point rating  
22 scale as less ambiguous, ambiguous or most ambiguous. Based on the ratings, the items were  
23 modified till a rating of 'least ambiguous' is obtained for all the items by the same raters.

1 Therefore, the final set of stimuli consisted of colored line drawings of five most common nouns  
2 (cat, chair, house, pen & tree) arranged in an array of 50 items (5 rows\*10 columns). The items  
3 were repeated 10 times each and distributed on a random basis in the array. The entire array was  
4 printed on an A3 size sheet for good visibility and presented to the participants.

5

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

9

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

14

15 A familiarity check was carried out to ensure that the participants were familiar with the  
16 stimuli used as test items. They were instructed to name each of the five test items presented as  
17 picture cards. The participants were then explained about the RAN task (verbal & non-verbal),  
18 followed by practice trials. The practice trial was carried out using an array of 12 items (3  
19 rows\*4 columns), which were different from the test items. The participants were instructed in  
20 English and in instances of uncertainty about the procedure instructions were repeated in their  
21 native language (Kannada) for better understanding.

22

23 **Instructions and scoring:**

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

4  
5 *RAN non-verbal:* In the RAN non-verbal task, the participants were asked to point to all  
6 occurrences of the indicated target item in the complete array as quickly and as accurately as  
7 possible in a serial manner. This was carried out for each of the five target items and the total  
8 time taken for pointing to all the target stimuli was calculated.

9  
10 *Reading:* In the reading task, children were asked to read the words in the given list. Each  
11 participant was instructed to read all the words as fast and as accurately as possible. The time  
12 taken to read all the words was noted.

## 13 14 **Results**

15  
16 The present study aimed to investigate the rapid automatized processing of nouns in two  
17 modalities (verbal and non-verbal) and its correlation with reading skills in typically developing  
18 children. The total duration to perform each of the tasks (RAN verbal, RAN non-verbal &  
19 reading) was noted individually. The mean duration and standard deviation for rapid processing  
20 of nouns in two modalities (verbal and non-verbal) and reading for all participants are given in  
21 Table 1.

22  
23



1 **Table 1**

2 *Mean duration (in sec) and Standard Deviation (S.D.) for RAN verbal, RAN non-verbal and*

3 *Reading tasks*

	U.K.G.		Grade 1	
	Mean	S.D.	Mean	S.D.
<b>RAN verbal</b>	59.00	10.92	54.86	6.46
<b>RAN non-verbal</b>	55.40	11.50	49.66	9.20
<b>Reading</b>	47.06	13.72	35.93	7.67

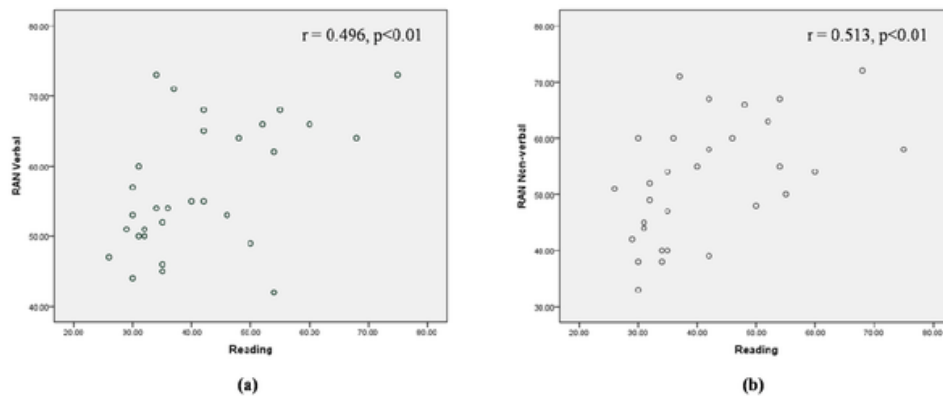
4

5 The mean duration for processing nouns was found to be different in the two modalities  
6 as shown in Table 1. The mean duration for the non-verbal task i.e., pointing was found to be  
7 lesser when compared to the verbal task of naming. It was found that Grade 1 participants  
8 performed better than participants from U.K.G. on all the three tasks of naming, pointing and  
9 reading.

10

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

1 The study also aimed to understand the correlation between reading and rapid processing  
2 in the two modalities respectively. As there was no significant grade effect, correlation analysis  
3 was performed on the combined data for grade. Pearson product-moment correlation indicated a  
4 significant positive correlation between rapid processing of nouns and reading in both verbal ( $r =$   
5  $0.496, p < 0.01$ ) and non-verbal ( $r = 0.513, p < 0.01$ ) modalities as depicted in Figure 1.



6  
7 *Figure 1:* Scatter plot depicting the correlation of Reading with (a) RAN Verbal and (b)  
8 RAN Non-verbal  
9

## 10 Discussion

11  
12 The present study investigated the rapid processing of nouns in both verbal and non-  
13 verbal modalities and its correlation with reading. The findings suggest no statistically  
14 significant difference in the rapid processing between the two grades. These findings are in  
15 consensus with the earlier study by Biddappa et al. (2016). However, it may be reiterated that the  
16 findings should be generalized with caution.

17

1           In addition to the grade, there were no significant effects of modality on performance of  
2 rapid processing tasks. This finding reflects similarities in verbal and nonverbal processing  
3 supporting the findings of our earlier investigation (Biddappa et al., 2016). Similar processing of  
4 nouns in the two modalities could be attributed to the automatization of noun class of words.  
5 Nouns are reported to be acquired in the early years of language acquisition (Gentner, 1982;  
6 Golinkoff & Hirsh-Pasek, 2008). Furthermore, researchers agree to the fact that nouns are  
7 usually predominant <sup>7</sup> in both receptive and expressive vocabularies of young <sup>24</sup> children (Bornstein,  
8 Cote, Maital, Painter, Par, Pascual, Pecheux, Rue, Venuti, & Vyt, 2004; Umek, Fekonja-Peklaj,  
9 & Podlesek, 2013). It can be speculated that early acquisition and extensive usage of nouns  
10 during the developmental years is reflected as automatic processing with no significant  
11 differences observed between the two modalities. These findings corroborate with the findings of  
12 Katz et al. (1982) who suggested that both verbal and manual RAN measures share lexical  
13 representations, memory and perceptuomotor processes. Therefore, it is plausible that the sharing  
14 of these processes in the two modalities could have led to no significant differences in the two  
15 modalities.

16  
17           The study also investigated the relationship between rapid processing of nouns in two  
18 modalities and reading. A significant positive correlation was found between rapid processing of  
19 nouns in the two modalities and reading. Earlier reports in the literature have supported the  
20 positive correlation between RAN and reading (Georgiou, Parrila, Cui, & Papadopoulos, 2013;  
21 Allor, 2002; Cutting & Denckla, 2001; Wolf & Bowers, 1999). RAN and reading are reported to  
22 share a series of common processes including <sup>6</sup> eye saccades, working memory, connection of

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

3

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

12

### 13 Conclusions

14

15 The study adds to the existing literature and enhances our understanding on the  
16 significance of rapid processing skills in young, typically developing children and its role in  
17 reading abilities. Similar processing in both verbal and non-verbal modalities serve as the  
18 behavioral evidence on the commonalities of verbal and non-verbal processing in addition to the  
19 existing neuroanatomical correlates and processing mechanisms. The correlation of non-verbal  
20 mode of assessment with reading offers a new perspective to assess rapid processing and predict  
21 reading skills in children with limited verbal skills in whom administration of traditional RAN  
22 tasks poses a challenge. However, the results should be generalized with caution and future  
23 investigations of rapid processing skills through non-verbal modalities and its correlation with

1 reading in children with different developmental disorders may offer greater insights in this  
2 regard.

3

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1 **Table legend**

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

	<b>U.K.G.</b>		<b>Grade 1</b>	
	<b>Mean</b>	<b>S.D.</b>	<b>Mean</b>	<b>S.D.</b>
<b>RAN verbal</b>	59.00	10.92	54.86	6.46
<b>RAN non-verbal</b>	55.40	11.50	49.66	9.20
<b>Reading</b>	47.06	13.72	35.93	7.67

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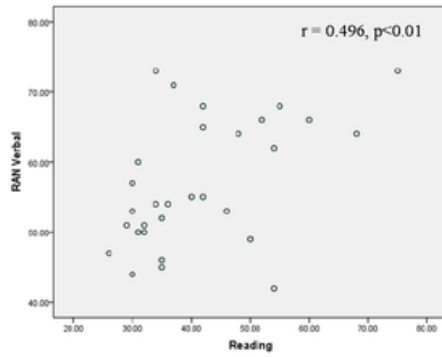
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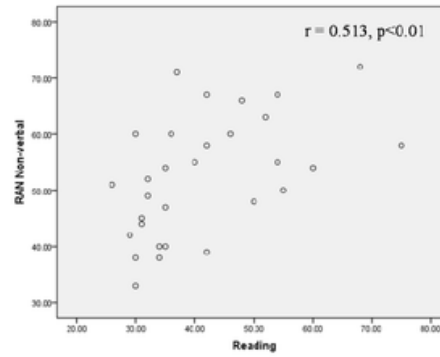
1 Figure legend

2 *Figure 1:* Scatter plot depicting the correlation of Reading with (a) RAN Verbal and (b) RAN  
3 Non-verbal

4



(a)



(b)

5

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