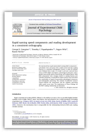
Why is rapid automatized naming related to reading?

T. C. Papadopoulos



Journal of Experimental Child Psychology 115 (2013) 218–225

Contents lists available at SciVerse ScienceDirect

Journal of Experimental Child Psychology

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

Brief Report

Why is rapid automatized naming related to reading?

George K. Georgiou [a,*], Rauno Parrila [a], Ying Cui [a], Timothy C. Papadopoulos [b,c]

[a] Department of Educational Psychology, University of Alberta, Edmonton, Alberta, Canada T6G 2G5
[b] Department of Psychology, University of Cyprus, 1678 Nicosia, Cyprus
[c] Centre of Applied Neuroscience, University of Cyprus, CY 1678 Nicosia, Cyprus

ARTICLE INFO

Article history:
Received 13 March 2012
Revised 28 August 2012
Available online 4 February 2013

Keywords:
Rapid automatized naming
Reading
Lexical access
Phonological encoding
Seriality
Discrete naming

ABSTRACT

The objective of this study was to examine why rapid automatized naming (RAN) is related to reading by manipulating processes involved at the input, processing, and output stages of its production. In total, 65 children in Grade 2 and 65 in Grade 6 were assessed on serial and discrete RAN (Digits and Objects), Cancellation, RAN Yes/No, and oral and silent reading fluency. The results of regression analyses indicated that RAN is related to reading because both involve serial processing and oral production of the names of the stimuli.

Introduction

Research on rapid automatized naming (RAN)—the ability to name, as quickly as possible, visually presented familiar symbols such as digits, letters, colors, and objects—is now celebrating its 40th anniversary (Denckla, 1972). Despite the plethora of studies documenting its importance for reading (e.g., de Jong & van der Leij, 1999; Georgiou, Torppa, Manolitsis, Lyytinen, & Parrila, 2012; Landerl & Wimmer, 2008; Papadopoulos, Georgiou, & Kendeou, 2009; Powell, Stainthorp, Stuart, Garwood, & Quinlan, 2007; Scarborough, 1998), the reason why it is related to reading remains unclear (e.g., Kirby, Georgiou, Martinussen, & Parrila, 2010). The purpose of this study was to examine why RAN is related to reading by manipulating processes involved at the input, processing, and output stages of its production. To our knowledge, only few studies have experimentally manipulated factors that may account for the RAN–reading relationship, and they have done so in a rather fragmented fashion (e.g., Compton, 2003; de Jong, 2011; Di Filippo et al., 2005; Jones, Obregón, Kelly, & Branigan, 2008; however, see also Scarborough & Domgaard, 1998).

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

0022-0965/$ - see front matter
http://dx.doi.org/10.1016/j.jecp.2012.10.015

The first studies focused on the input stage and specifically on whether or not the format of the RAN tasks (serial vs. discrete) plays a role in the RAN–reading relationship (see Kirby et al., 2010, for a review). If RAN and reading are related because both involve naming stimuli in serial order, then serial RAN should produce stronger correlations with reading than discrete RAN. Indeed, several studies have found that serial RAN is a stronger predictor of reading than discrete RAN (e.g., Bowers & Swanson, 1991; Chiappe, Stringer, Siegel, & Stanovich, 2002). A common characteristic of these studies is that the score on discrete RAN was the time between the onset of stimulus presentation on a computer screen and the onset of response articulation. Thus, strictly speaking, the two formats of RAN tasks have not been comparable because they differ not only on seriality but also on articulation (with articulation being part of only serial RAN).

Researchers have also examined the effects of set size (the number of items to be accessed and produced in a RAN task) on the RAN–reading relationship. Increasing the set size is assumed to increase the phonological encoding demands because children would need to access and retrieve the names of different symbols more frequently. Set size studies have been conducted with samples of poor/dyslexic readers and their controls and have reported conflicting findings (e.g., Di Filippo, Zoccolotti, & Ziegler, 2008; Georgiou, Parrila, & Hung, 2009; Scarborough & Domgaard, 1998). Georgiou and colleagues (2009), for example, developed two versions of the Letter and Object Naming task—5 objects/letters repeated 16 times versus 20 objects/letters repeated 4 times—and measured their effect on the performance of high-functioning adult dyslexics and controls. Their results indicated that the group by set size interaction was not significant, suggesting that the dyslexic individuals performed equally poorly on both set size conditions. In contrast, Di Filippo and colleagues (2008) reported that increasing the set size in Object and Digit Naming from 5 items repeated 10 times to 50 unrepeated items resulted in an increase in the difference between normal readers and children with dyslexia.

Finally, research has been conducted on the output stage of RAN's production. For example, Di Filippo and colleagues (2005) compared the contribution of two RAN tasks that differed in their naming requirements on reading. In the first task children were asked to name aloud all of the stimuli (as in any traditional RAN task), and in the second task they were asked to cross out a specified stimulus (e.g., 9 in Digit Naming) every time they came across it. The results indicated that only the naming condition correlated significantly with reading. Because Articulation Rate, a task in which children pronounced numbers from 101 to 110 as quickly as possible, did not predict reading either, Di Filippo and colleagues concluded that deficits in RAN reflect slow access to phonological representations rather than visual input (operationalized by the Cancellation task) or phonological output (operationalized by the Articulation Rate task) deficits.

The natural follow-up question is whether any kind of verbal response in serial RAN produces significant correlations with reading. The studies examining this have produced mixed findings. Scarborough and Domgaard (1998) showed that a task in which children said "yes" every time they saw a target letter and "no" for the rest of the stimuli did not correlate significantly with reading. However, Jones, Branigan, Hatzidaki, and Obregón (2010) found that performance in an object categorization RAN task (where participants said "yes" if the item in the RAN task was a living object and "no" if it was not) produced equally strong effects on adults with dyslexia as a traditional Object Naming task. Jones and colleagues argued that "a difficulty in explicit access to, and output of, an item's name does not further account for dyslexic readers' impairment beyond their difficulty in accessing and outputting information related to the item's semantic properties" (p. 65), suggesting that phonological representations are not the critical feature of the RAN–reading relationship.

The current study

Given the growing importance of RAN for both theory and practice (see Kirby et al., 2010, for a review), it is imperative to seek a firmer understanding of the reason(s) why it is related to reading. In designing our study, we reasoned that, everything else being equal, if X is the process that is responsible for the RAN–reading relationship, then increasing or decreasing the demands of X should result in an increase or decrease in the RAN–reading relationship.

The current study aimed to answer the following questions:

(1) Does seriality contribute to the RAN–reading relationship? If yes, then the traditional RAN task should be more strongly related to reading than discrete RAN (with or without articulation).
(2) Does set size contribute to the RAN–reading relationship? If yes, then a stronger relationship with reading should be observed when naming 10 stimuli repeated 5 times than when naming 5 stimuli repeated 10 times or 2 stimuli repeated 25 times.
(3) Does naming the specific stimuli in the RAN tasks contribute to the RAN–reading relationship? If yes, then the traditional RAN task (5 items repeated 10 times) should be more strongly related to reading fluency than a task in which the participants say ‘‘yes'' or ‘‘no'' or a task in which the participants cross out a target stimulus.

Method

Participants

The participants were 65 children in Grade 2 (28 girls and 37 boys, mean age = 94.82 months, *SD* = 3.71) and 65 children in Grade 6 (30 girls and 35 boys, mean age = 142.91 months, *SD* = 3.28). All of the participants were Greek-speaking Cypriot children. They were monolingual Caucasians and had no documented cognitive, sensory, or behavioral difficulties. General cognitive ability, measured with Block Design and Expressive Vocabulary (from the Wechsler Intelligence Scale for Children [WISC-III]; Georgas, Paraskevopoulos, Bezevegis, & Giannitsas, 1997) was within the average range (the mean standard scores for Block Design were 10.37 [*SD* = 2.71] and 10.86 [*SD* = 2.53] for Grades 2 and 6, respectively, and those for Expressive Vocabulary were 9.21 [*SD* = 3.46] and 9.02 [*SD* = 3.73] for Grades 2 and 6, respectively).

Measures

Serial RAN

The participants were asked to name, as quickly as possible, recurring digits and objects that were arranged semi-randomly in five rows of 10. Both tasks had three conditions. In Condition 1, 5 digits (2, 4, 5, 7, and 9) or objects (ball, cat, tree, chicken, and apple) were repeated 10 times. In Condition 2, 2 digits (2 and 5) or objects (apple and chicken) were repeated 25 times. In Condition 3, 10 digits (from 0 to 9) or objects (cheese, foot, baby, ruler, belt, ball, cat, tree, chicken, and apple) were repeated 5 times. A participant's score in each condition was the total time needed to name all of the stimuli. Because few naming errors occurred, they were not considered further.

Discrete RAN

The five digits and objects used in Condition 1 of serial RAN were used to assess discrete naming speed. Each stimulus was presented individually in the center of a computer screen, with a brief (500-ms) blank screen between presentations. Stimuli were presented in a random order, and each stimulus was presented three times for a total of 15 trials for digits and 15 trials for objects. The time between the presentation of each stimulus and the onset of the vocal response was measured with voice onset reaction time, and the average latency was calculated across all 15 presentations. The responses were also recorded and analyzed with sound editing software (Goldwave 5.23) to calculate the mean articulation time for digits and objects. Naming errors were rare (1.5% of the responses in Grade 2% and 0.5% of those in Grade 6) and were not considered further. In addition, the response times associated with naming errors were excluded from the calculations.

Cancellation

In the Cancellation task, the children viewed a card similar to that in Condition 1 (the items were rearranged) and were asked to cross out, row by row and as quickly and accurately as possible, the target stimulus (9 for Digit Naming and tree for Object Naming). A participant's score was the total time needed to cancel out all of the target stimuli.

Yes/No Naming

In the Yes/No Naming task, the children viewed a card similar to that in Condition 1 (the items were rearranged) and were asked to say "yes" every time they came across 7 in Digit Naming or cat in Object Naming and to say "no" for all other stimuli. A participant's score was the total time needed to name all of the stimuli.

Reading fluency

Oral reading fluency was assessed with Word Reading Efficiency and Phonemic Decoding Efficiency tasks that were adapted in Greek from the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999; for the adaptation procedure, see Georgiou, Papadopoulos, Fella, & Parrila, 2012). In the Word Reading Efficiency task, the children were asked to read, as quickly as possible, a list of 104 words of increasing difficulty divided into four columns of 26 words each. In the Phonemic Decoding Efficiency task, the children were asked to read, as quickly as possible, a list of 63 pseudowords. A short, 8-word/nonword practice card was presented before each subtest. A participant's score was the number of correct words/nonwords read within a 45-s time limit. Georgiou and colleagues (2012) reported test–retest reliability for the Word Reading Efficiency task in Grades 2 and 6 to be .92 and .93, respectively, and for the Phonemic Decoding Efficiency task to be .86 and .89, respectively.

Silent reading fluency was assessed with the Wordchains task, which was adapted from the work of Jacobson and colleagues (e.g., Jacobson, 1999; Jacobson & Lundberg, 2000). In this task, the children were asked to scan words presented as a continuous line of print without interword spaces (e.g., *boygomeet*) and to identify the words by drawing a line to indicate where the spaces should be (e.g., *boy/go/meet*). The test had a total of 15 rows of words of increasing length. The first 2 rows consisted of two words put together, whereas the last 3 rows consisted of seven words put together. The words were one or two syllables and were selected from the Grade 1 and 2 language textbooks. A participant's score was the number of correctly placed slashes (max = 70) in 1 min. The Cronbach's alpha reliability coefficient in our sample was .81 in Grade 2 and .89 in Grade 6. In addition, Wordchains correlated $r = .45$ with a composite score of oral reading fluency in Grade 2 and $r = .55$ in Grade 6.

Procedure

The participants were assessed individually in a quiet room by the first author and a graduate student during school hours. Testing took place in April/May and was completed in three sessions, each lasting approximately 25 min. The order of the sessions and the tasks within each session were counterbalanced.

Results

Preliminary analyses

The descriptive statistics for each measure and for each grade are presented in Table 1. The distributions of all serial RAN Digits and Objects Naming scores were positively skewed due to two outliers at the slow end of the distributions. To normalize the distributions, we Winsorized the scores of the outliers to the next non-outlier's score plus 1 (Tabachnik & Fidell, 2001). Before running any regressions analyses, we created a composite score for oral reading fluency by averaging the z scores of Word Reading Efficiency and Phonemic Decoding Efficiency (the two measures correlated $r = .88$ in both grades).

Results of regression analyses

To examine the role of the different versions of RAN tasks on oral and silent reading fluency, we performed three sets of multiple regression analyses (see Models 1–3 in Table 2). In Model 1, we examined the effects of serial RAN (5×10) and discrete RAN (with and without articulation) on oral

Table 1
Descriptive statistics of all measures used in the study.

	Grade 2				Grade 6			
	M	*SD*	Min	Max	*M*	*SD*	Min	Max
Input stage								
RAN Digits (5 × 10)	31.05	6.00	21.53	47.71	21.35	2.92	13.90	27.53
RAN Digits discrete	0.07	0.01	0.04	1.12	0.06	0.01	0.42	0.84
RAN Digits discrete with articulation	1.16	0.02	0.08	1.56	0.09	0.12	0.68	1.19
RAN Objects (5 × 10)	56.00	11.09	37.61	83.43	38.22	6.59	25.72	54.63
RAN Objects discrete	0.08	0.02	0.05	1.26	0.71	0.12	0.47	1.02
RAN Objects discrete with articulation	1.46	0.02	1.05	2.08	1.20	0.18	0.83	1.60
Processing stage								
RAN Digits (2 × 25)	29.63	4.18	23.08	41.64	20.76	2.63	15.90	26.48
RAN Digits (10 × 5)	32.34	6.71	22.58	48.22	21.35	3.57	13.23	30.34
RAN Objects (2 × 25)	34.48	5.75	25.53	48.22	24.19	3.41	17.93	31.57
RAN Objects (10 × 5)	60.05	11.66	37.29	88.13	39.71	8.01	27.39	58.62
Output stage								
RAN Digits Cancellation	15.79	3.59	7.75	24.18	9.95	2.11	6.66	16.83
RAN Digits Yes/No	32.88	5.19	23.02	49.44	23.86	4.31	17.02	34.30
RAN Objects Cancellation	13.38	3.22	6.66	19.93	8.53	2.09	5.06	15.25
RAN Objects Yes/No	29.96	4.49	24.80	44.15	22.45	3.63	16.21	33.12
Reading								
Word Reading Efficiency	43.26	11.85	21	78	72.43	13.66	43	103
Phonemic Decoding	28.78	6.12	13	42	44.65	8.63	25	63
Wordchains	10.40	5.30	2	24	29.20	8.85	10	44

Note. RAN, rapid automatized naming. A higher score in the RAN tasks indicates slower performance. $N = 65$ in each grade.

and silent reading fluency. Because discrete naming with articulation encompasses discrete naming, we ran two separate regression analyses within Model 1 (see Models 1A and 1B). In Model 2, we examined the effects of set size by comparing the effects of RAN (2 × 25), RAN (5 × 10), and RAN (10 × 5). Finally, in Model 3, we examined the role of articulation by comparing the effects of RAN (5 × 10), RAN Cancellation, and RAN Yes/No. Standardized beta coefficients, significance levels, and total amount of variance explained by the model are presented in Table 2.

Model 1 results show that only RAN (5 × 10) significantly predicted oral reading fluency in both grades and silent reading fluency in Grade 6. Model 2 results show that RAN–O (10 × 5) was the only significant predictor of oral and silent reading fluency in Grade 2 and RAN–D (10 × 5) was the only significant predictor of oral and silent reading fluency in Grade 6. Finally, Model 3 results show that RAN (5 × 10) was the only significantly predictor of oral reading fluency in both grades and of silent reading fluency in Grade 6.

Discussion

Our results suggest first that RAN and reading are related because both require serial processing. Only serial RAN significantly predicted reading fluency, and this finding was similar across grades. However, seriality alone does not appear to be a sufficient explanation for why RAN is related to reading because both RAN Cancellation and RAN Yes/No required serial processing but did not correlate with reading as strongly as the standard serial RAN task that also required the articulation of specific names (see Scarborough & Domgaard, 1998, for a similar finding).

Beyond seriality, RAN is related to reading because it requires pronunciation of specific names. This conclusion is supported by two pieces of evidence. First, with few exceptions, the amount of explained variance in oral reading fluency was at least twice as large as in silent reading fluency (see Moll, Fussenegger, Willburger, & Landerl, 2009, for similar findings). Second, although in both RAN Yes/No and RAN (2 × 25) the participants were asked to produce two oral responses (yes or no, 2 or 5, and apple or chicken), only RAN (2 × 25) correlated significantly with oral reading fluency, and the correlations were twice as large as in RAN Yes/No.

Table 2

Results of multiple regression analyses with oral and silent reading fluency as outcome measures.

Model	Variable	Grade 2						Grade 6					
		Oral reading fluency			Silent reading fluency			Oral reading fluency			Silent reading fluency		
		r	*β*	R^2	*r*	*β*	R^2	*r*	*β*	R^2	*r*	*β*	R^2
Input stage													
1A	RAN–D (5 × 10)	−.56**	−.587***	.32	−.11	−.067	.03	−.61**	−.627***	.38	−.34**	−.311*	.12
	RAN discrete	−.03	.122		−.17	−.156		−.12	−.059		−.17	−.088	
1B	RAN–D (5 × 10)	−.56**	−.619***	.30	−.11	.010	.05	−.61**	−.675***	.39	−.34**	−.284*	.13
	RAN discrete with articulation	−.18	.162		−.23	−.234		−.17	.141		−.25	−.121	
1A	RAN–O (5 × 10)	−.35*	−.435**	.14	−.19	−.141	.04	−.69**	−.737***	.50	−.47**	−.446***	.22
	RAN discrete	−.07	.168		−.17	−.093		−.09	.134		−.20	−.066	
1B	RAN–O (5 × 10)	−.35*	−.394**	.11	−.19	−.277	.05	−.69**	−.745***	.48	−.47**	−.388**	.23
	RAN discrete with articulation	−.09	.151		−.05	.117		−.20	.149		−.34*	−.158	
Processing stage													
2	RAN–D (2 × 25)	−.43**	−.117	.36	−.06	−.013	.01	−.57**	−.064	.46	−.34**	−.046	.17
	RAN–D (5 × 10)	−.56**	−.160		−.11	−.135		−.61**	−.206		−.34**	−.010	
	RAN–D (10 × 5)	−.59**	−.378		−.09	.040		−.66**	−.447*		−.41**	−.368	
2	RAN–O (2 × 25)	−.36**	.007	.31	−.27*	−.071	.14	−.55**	−.115	.50	−.39**	−.120	.25
	RAN–O (5 × 10)	−.35*	.277		−.19	.254		−.69**	−.435*		−.47**	−.171	
	RAN–O (10 × 5)	−.53**	−.764***		−.34**	−.500*		−.65**	−.214		−.47**	−.253	
Output stage													
3	RAN–D (5 × 10)	−.56**	−.536***	.31	−.11	−.049	.05	−.61**	−.585***	.38	−.34**	−.294*	.19
	RAN–D Cancellation	−.15	−.028		−.21	−.180		−.19	−.075		−.33**	−.281*	
	RAN–D Yes/No	−.21	−.049		−.13	−.073		−.25	−.040		−.17	.007	
3	RAN–O (5 × 10)	−.35*	−.321*	.13	−.19	−.144	.09	−.69**	−.718***	.49	−.47**	−.421***	.27
	RAN–O Cancellation	−.09	.009		−.27*	−.246		−.17	.022		−.34**	−.210	
	RAN–O Yes/No	−.18	−.105		−.07	.029		−.19	.048		−.16	.065	

Note. RAN–D, Digit Naming; RAN–O, Object Naming. The *r* values are Pearson product–moment correlation coefficients between the RAN measures and the reading fluency outcomes. $N = 65$ in each grade.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

The set size did not matter for the RAN–reading relationship. Even when the set involved two items, we observed significant correlations with reading (see Table 2) that were not much lower than the correlations between RAN (5×10) or RAN (10×5) and reading fluency. In addition, the mean differences among the various set size versions of Digit Naming were small (see Table 1). Because these measures differed only in set size, this might suggest that similar processes underlie these measures. Consequently, differences in the correlations with reading should not be expected.

The findings of our study complement those of previous studies that used a different methodology to examine the RAN–reading relationship and documented a role for the input system (e.g., Bowers, 2001; Breznitz, 2005; Stainthorp, Stuart, Powell, Quinlan, & Garwood, 2010). For example, Stainthorp and colleagues (2010) compared the performance of children with slow and fast RAN performance on several visual processing tasks and found that the children with slow RAN performance were significantly slower to make same/different judgments to simple visual features and non-nameable letter-like characters. Importantly, this deficit was independent of speed of processing, phonological awareness, and reading ability. However, we argue here that it is not only visual pattern recognition that underlies the RAN–reading relationship but also oral production of specific names that requires access to well-specified phonological representations.

Some limitations of the current study are worth mentioning. First, our findings might only generalize to other languages with characteristics similar to those of Greek (e.g., German, Dutch, Spanish). Previous studies have shown that there may be differences in the importance of RAN on reading across languages varying in orthographic consistency (see Georgiou, Parrila, & Papadopoulos, 2008; Mann & Wimmer, 2002; McBride-Chang & Kail, 2002). If the format of presentation and the pool from which the items are retrieved are the same across languages, then differences in the RAN–reading relationship across languages can only be attributed to differences in articulation (on the condition that the reading measures are also comparable). Second, our sample size was modest, and future studies should try to replicate these findings with a larger sample size. Third, we did not administer RAN Letters because it does not work properly in Greek. Children are first taught in school the letter sounds, and when they are asked to provide the letter names they make many naming errors or self-corrections, both of which interfere with the automatic nature of the task. Fourth, the Wordchains task was not strictly comparable to the oral reading fluency measures. Although it is similar to other silent reading fluency measures (see Test of Silent Word Reading Fluency; Mather, Hammill, Allen, & Roberts, 2004) and no verbal response was required, we cannot preclude the possibility that children were preparing some sort of articulation in order to decide where to place the slash. Finally, because of the consistency of Greek orthography, we used reading fluency measures to assess reading ability. However, RAN and reading fluency are both speeded measures, and this may have inflated their relationship. Future studies in English should replicate these findings using reading accuracy measures as well.

To conclude, RAN appears to be related to reading because both tasks require serial processing and active production of specific names. The findings were consistent across RAN tasks and grade levels. Manipulating the set size (and, by doing this, the phonological encoding demands) did not significantly affect the RAN–reading relationship (see Georgiou et al., 2009, for similar findings in English-speaking adults). This suggests that as long as there is some access to phonological representations, RAN will be related to reading.

Acknowledgment

We thank Dr. Hollis Scarborough for her helpful comments on an earlier version of the manuscript.

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