PHONOLOGICAL SIMILARITY, WORD LENGTH AND RAPID NAMING

THE EFFECT OF PHONOLOGICAL SIMILARITY AND WORD LENGTH ON RAPID NAMING PERFORMANCE

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Abstract

The ability to rapidly and continuously update phonological representations is critical to skilled reading. Denkla and Rudel (1976) first reported Rapid Naming impairments in poor readers, leading to a wide body of evidence supporting the Rapid Naming task as a reliable predictor of reading success. Despite a well-established correlation between Rapid Naming performance and reading achievement, the factors driving this relationship remain unclear. The present study was an exploratory investigation of the role of articulatory planning in Rapid Naming performance. Specifically, we explored the effects of phonological similarity and word length of the items to-be-named in the Rapid Naming task. Naming times were measured in 30 Undergraduate students with typical reading ability, and 10 poor reading high school students completing the standard Rapid Naming task, as well tasks manipulated for phonological similarity and word length. The results showed that phonologically similar words generated significantly longer naming times than the standard Rapid Naming task for both typical and poor readers. This finding suggests that when phonological representations are similar, it creates competition for the rapid updating of representations during motor planning for naming. Additionally, 3-syllable items for typical readers and 2-and 3-syllable items for poor readers produced significantly longer naming times than the standard Rapid Naming task, suggesting that larger phonological representations also create competition in motor planning. The results of the preset study suggest that phonological similarity and word length have a similar influence on Rapid Naming ability in typical and poor readers.

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Declaration of Academic Achievement

The present study was designed by the author, Kendall Kolne, through collaboration with her supervisor, Dr. E. Service, her committee member Dr. C. Anderson and members of the Language, Memory and Brain Lab. Data collection for the university undergraduates was conducted by Kendall Kolne. Kendall Kolne conducted data collection for the high school students, with the assistance of Allana Hoy, Ana Nunes and Regina Henry. Kendall Kolne conducted data analysis, through collaboration with Dr. Service. The thesis paper was written by Kendall Kolne, with suggestions and edits provided by Dr. Service and Dr. Anderson.

Introduction

Phonological Processing and Reading Ability

Developmental dyslexia was first described over 100 years ago, but the etiology of the disorder is still the subject of debate. An impairment of phonological processing has been the most predominant symptom and the most widely supported cause associated with the development of poor reading and dyslexia. It is necessary for the beginning reader to be aware of and make use of the structure and sounds of language, and be able to map the phonemes of a language onto the orthography. There is a wide body of evidence to suggest that a failure in the processing of phonological information is the biggest contributor to poor reading (ex. Fox & Routh, 1980; Liberman, Shankweiler & Liberman, 1989; Wagner & Torgesen, 1987; Wagner, Torgesen & Rashotte, 1994).

Fox and Routh (1980) were some of the earliest authors to report an association between the processing of phonological information and reading ability. In their study, Fox and Routh (1980) tested typically reading children, children with a mild reading difficulty and children with a severe reading difficulty. All of the children were tested on their ability to segment spoken syllables into phonemes. Fox and Routh (1980) found that children with severe reading difficulties were unable to segment the syllables into phonemes, performing significantly worse than the children with mild reading difficulties, and the children with typical reading ability (both of which were skilled at syllable segmentation). A wide body of literature followed this paper, replicating the findings of Fox and

Routh, providing strong evidence for a role of phonological processing impairments in poor readers.

Similar to Fox and Routh, who report impairments at the level of phonological structure, Mann and Liberman (1984) provided evidence for phonological processing impairments associated with poor reading at the level of the syllable. Mann and Liberman (1984) tested children in kindergarten on a syllable counting task. The children were instructed to orally repeat words of increasing length, while simultaneously tapping to each syllable in the word. The same children were tested again in grade 1, after they had begun to learn to read. This time, a test of reading ability was administered, and the children were divided into groups, based on reading ability. The results of the longitudinal study by Mann and Liberman (1984) indicate that significantly fewer children categorized as 'average readers' in grade 1 performed successfully on the syllable counting task in kindergarten than the children categorized as 'good readers'. Additionally, significantly fewer children categorized as 'poor readers' in grade 1 performed successfully on the syllable counting task in kindergarten than those categorized as good readers. Mann and Liberman (1984) provide evidence for impairments of phonological processing at the syllabic level in poor readers. Additionally, this study was the earliest of many to provide evidence that pre-reading measures of phonological processing may predict later reading ability (Mann & Liberman, 1984).

Despite a considerable body of empirical support, it is argued that there is not enough evidence to indicate a causal role of phonological processes in

reading disability (Pennington, et al., 1991). Castles and Coltheart (2004) conducted an extensive review of the research on phonological awareness and reading, examining whether or not phonological awareness precedes and directly affects reading acquisition. There was little direct evidence from this review to support a causal connection between pre-reading phonological awareness skills and later reading and spelling skills. In addition to this research, Ramus and Szenkovits (2008) reviewed a body of literature suggesting phonological representations might be intact in dyslexic individuals. These authors argue that time and short-term memory constraints elicit the phonological deficits, and that in the absence of these constraints, dyslexic individuals are able to form appropriate representations (Ramus & Szenkovits, 2008). Thus, it seems that there is not enough evidence to support the role of phonological awareness impairments as single causes in dyslexia or poor reading, and that alternative explanations must be considered.

Rapid Naming and Reading Ability

In addition to deficits of phonological awareness, a second core deficit, affecting rapid naming of multiple targets, has gained support as another critical impairment in dyslexia,. Research on this task began with Gechwind (1965), who suggested that the cognitive processes involved in colour naming, specifically attaching a verbal label to a visual item could be an early predictor of later reading success. One of the earliest investigations of this suggestion came from Denckla and Rudel (1976), who reported impaired performance in children with dyslexia on rapid repetitive naming of colours, letters, numbers and objects, as

compared to normal-reading-level controls. Moreover, Denckla and Rudel (1976) reported that dyslexic children demonstrate impaired performance on the Rapid Naming task as compared to non-dyslexic, learning disabled children, differentiating these two populations. Denckla and Rudel (1976) argue that the impaired performance of dyslexic children is not the result of a general slowness of reaction times. According to them, it reflects an impairment of visual-verbal association, which these authors call “automatization”. It is suggested that a failure to “automatize” the association between visual information and a verbal/motor output is a critical impairment in dyslexia. However it is unclear what produces the failure in automatization (Denckla & Rudel, 1976).

The association between difficulty in Rapid Naming performance and poor reading reported by Denckla and Rudel (1976) has lead to several demonstrations that speed in a Rapid Naming task is a strong predictor of reading success (e.g. Blachman, 1984; Stanovich, 1981; Vellutino et al., Wolf, 1991). Additionally, naming speed deficits have been reported in dyslexic individuals across languages, including German (Wimmer, 1993), Finnish (Korhonen, 1995) and Dutch (Van den Bos, 1998; Yap & Van der Leij, 1993). Despite the wide body of evidence supporting the relationship between reading ability and Rapid Naming performance, the factors driving the relationship remain unclear.

Rapid Naming and Phonological Processing.

There are three dominant hypotheses in the literature, attempting to explain the relationship between Rapid Naming and reading ability. The first of these posits that Rapid Naming is a component of phonological processing (e.g., Torgesen, Wagner, Simmons & Laughon, 1990; Wagner, et al., 1993; Wagner, Torgesen, & Rashotte, 1994). For example, Torgesen, et al. (1990) argue that articulation rate can account for much of the relationship between Rapid Naming performance and reading ability. Specifically, Torgesen, et al. (1990) believe that the Rapid Naming task is a good articulation rate measure which taps into the underlying phonological code retrieval problems of poor readers.

Wolf (1997) disputes the argument that naming speed deficits are caused by an underlying phonological coding impairment. Wolf (1997) argues for a Double-Deficit account of reading impairment, where phonological processing and naming speed problems contribute independently to reading difficulty and a combination of these factors leads to the most extreme reading impairment. Wolf (1997) bases this hypothesis on a body of evidence indicating that there is an independent contribution of phonological processing and naming speed in reading ability, as well as a lack of evidence to support a correlation between phonological processing and Rapid Naming ability.

The Double-Deficit account is consistent with the work of Blachman (1984), who compared performance of children on phonological processing and Rapid Naming tasks and their relationship with reading ability. Blachman (1984)

tested Kindergarten and First-Grade children on rapid naming of objects, colours and letters , as well as syllable-tapping and a rhyme production. The results of this study indicated that the phonological processing tasks (syllable-tapping and rhyme production) and the rapid naming tasks are associated with different components of linguistic processing in Kindergarten and Grade 1. In a later study, McBride-Change and Manis (1996) report that naming speed and phonological awareness account for independent variance in reading ability in poor readers in Grades 3 and 4. Thus, it seems that Rapid Naming requires cognitive abilities independent from phonological awareness, yet remains crucial to reading achievement.

Rapid Naming and Orthographic Knowledge.

Bowers and Wolf (1993) provide an alternative explanation to the idea that phonological processing impairments underlie Rapid Naming deficits in poor readers. In general, these authors argue that weak orthographic codes contribute to difficulty with symbol naming in the Rapid Naming task (Bowers & Wolf, 1993). They hypothesize that slow naming speeds are indicative of a disruption of precise timing, which affects the automatic activation of good orthographic codes (Bowers & Wolf, 1993). Manis, et al. (2000) provided evidence to support this hypothesized relationship between Rapid Naming ability and orthographic knowledge. These authors explored the relationships between phonological awareness, rapid naming ability and orthographic knowledge in second-graders. Manis, et al. (2000) found that rapid naming ability for numbers and letters

accounts for a significant amount of variance in reading ability, after removing the variance from vocabulary knowledge and phonological awareness.

Torgesen, Wagner, Rashotte, Burgess and Hecht (1997) provide evidence contrary to this explanation. Torgesen et al. (1997) studied the independent contributions of rapid naming skill and phonological awareness to the growth of orthographic skills, in a longitudinal study of children across two overlapping periods of development (second to fourth grade and third to fifth grade). Based on the results of a multiple regression analysis, Torgesen, et al. (1997) reported that when initial reading skills is entered into the regression first, rapid naming skill in second and third grade did not predict orthographic skill in the fourth and fifth grades, in either normal or disabled readers. Torgesen, et al. (1997) therefore found no evidence to suggest that rapid naming ability could predict the growth of accuracy in orthographic processing.

Research results from investigations of the role of rapid naming ability in predicting orthographic processing development remain contradictory. Cutting and Denckla (2000) note that there are potential conceptual problems with the association between rapid naming ability and orthographic knowledge. Specifically, they point out that even performance on the non-orthographic subtests of the Rapid Naming task (i.e. the object and colour subtests) can distinguish poor readers from typical readers. Cutting and Denckla (2000) argue that because both orthographic and non-orthographic rapid naming stimuli can distinguish normal readers from poor readers, the relationship between rapid

naming and orthographic knowledge may reflect a common process shared by both.

Rapid Naming and Memory Span.

As with research investigating the relationship between rapid naming performance and orthographic knowledge, evidence for a relationship between rapid naming performance and verbal memory span is conflicting. For example, Spring and Capps (1974) predicted that there should be a strong correlation between rapid naming ability and memory span, arguing that for poor readers, encoding speed causes rapid naming difficulties as well as recall of recently presented items. Spring and Capps (1974) tested good and poor readers aged 7 to 13 on a Rapid Naming task, as well as a probe recall task. In this task, participants were exposed to a series of cards labeled with various digits, then placed face down. They were then asked to select, from an array of cards, a card with a probe digit. In a pilot study, Spring and Capps (1974) used an eye-tracker to identify a strategy used by participants on the probe recall task. Participants were employing a *cumulative rehearsal strategy,* in which they would attempt to recall the previously remembered items each time a new item was introduced. Spring and Capps (1974) hypothesized that poor readers encode too slowly to effectively use such a strategy.

The results of Spring and Capps' (1974) study provided support for their hypothesis, as fewer poor readers than good readers employed a cumulative rehearsal strategy while completing the probe recall task. Moreover, Spring and

Capps report (1974) report that a significant proportion of the variance in memory performance could be accounted for by digit naming performance. The findings of this study suggest that the slow encoding of poor readers creates difficulty in employing effective rehearsal strategies, as well as impairing rapid naming performance (Spring & Capps, 1974).

Contrary to the findings of Spring and Capps (1974), Wagner et al. (1993) used a simple correlation to find that letter and digit naming were not significantly correlated with the digit span task (a measure of memory span). Additionally, Cornwall (1992) reported finding no significant correlation between rapid naming performance and a sentence memory span task. Similar to the phonological processing and the orthographic knowledge explanations, research supporting the memory span explanation for rapid naming impairments in poor readers remains conflicted. The present study will explore the dominant hypotheses for the association rapid naming and reading ability and will attempt to provide evidence for an alternative explanation for this relationship.

The Cognitive Processes Underlying Rapid Naming Performance

In order to understand the relationship between rapid naming performance and reading ability, it is necessary to understand the cognitive processes necessary to be successful at the Rapid Naming task. Currently, there are two dominant hypotheses that describe the processes that contribute to rapid naming performance, each of which is discussed below.

Processing Speed and Rapid Naming.

Processing speed is one of the cognitive abilities predominantly considered to underlie rapid naming performance. Kail and Hall (1994), for example, tested the hypothesis that rapid naming ability is a manifestation of age-related changes of global processing speed. The researchers tested typically developing children aged 8–13 on measures of processing speed, rapid naming and reading recognition and comprehension. The measures of speed of processing included the Coding task from the Wechsler Intelligence Scale for Children-Revised and the Visual Matching and Cross-Out tasks from the Woodcock-Johnson Tests of Cognitive Ability. The results of this study indicate that rapid naming performance is predicted by speed of processing measures and not by age (Kail & Hall,1994). These findings suggest that it may be general processing speed, and not age-related automaticity, that underlies rapid naming performance. However an exact description if what processing speed means has yet to be provided.

Articulation Rate and Rapid Naming.

Articulation rate has been studied as a contributor to rapid naming performance in a greater number of studies than processing speed. For example, Spring and Perry (1986) reported that digit naming speed accounted for a significant proportion of the variance in reading ability, and a large portion of this was also accounted for by an articulation task involving counting (in Cutting & Denckla, 2001: 681). Despite this evidence, Obregon (1994) reported that the

articulatory component of rapid naming was not the salient component driving differences between typical and impaired readers. Using a computer program which parsed the speech stream during rapid naming performance, Obregon (1994) found no differences between good and poor readers for the duration of each articulated word. Thus, as with speed of processing, evidence supporting the role of articulation rate in rapid naming ability remains conflicted.

The present study attempts to identify some of the cognitive processes that contribute to the association between rapid naming performance and reading ability. To change the cognitive demands of the task, we manipulated the items-to-be named on the standard naming task. Our manipulations were designed to influence specific cognitive processes necessary to complete the rapid naming task, so that we might identify influences on rapid naming time and explore differences in these influences between good and poor readers.

Manipulations of the Present Study

In order to name any given item on the rapid naming task, a mental phonological representation of that item must be accessed. To be successful at naming the items in the task quickly, it is necessary to rapidly and continuously update these phonological representations. Brady, Poggie and Rapala (1989) point out that in addition to metaphonological processes (such as phonological awareness), there are a number of other underlying phonological processes observed to be related to reading ability, including short-term memory and lexical access. Brady, et al. (1989) hypothesize that the difficulty observed in encoding

phonological information occurs at an abstract level, where it is necessary to create and maintain a phonological representation. It is possible that difficulty in creating and updating of phonological representations contributes to rapid naming difficulty in poor readers. The manipulations in the present study will explore the ability for good and poor readers to rapidly and continuously update phonological representations during the Rapid Naming task.

Phonological Similarity Manipulation.

In order to explore the ability to update phonological representations during the rapid naming task, we manipulated the phonological similarity of the items-to-be-named on the task. We explored variations to the Rapid Object Naming subtest from the Rapid Naming Task in the Comprehensive Test of Phonological Processing (CTOPP) (Wagner, Torgesen & Rashotte, 1999). In the first manipulation, each of the items to-be-named had the same onset (Same Onset manipulation), and in the second manipulation, each of the items to-be-named had the same rime (Rhyming manipulation).

As there is not sufficient evidence to suggest that our manipulations will have a specific influence on the data, the present study is exploratory, rather than hypothesis testing in nature. We expected that the phonological similarity manipulation would influence the ability of the participant to update the phonological representations of the items-to-be named in the task. It is possible that the similarity of the phonological representations could facilitate the rapid updating process, making naming time faster in the Rhyming and Same Onset

manipulations and compared to the standard Rapid Object Naming task. Alternatively, similarity could create competition in the rapid updating of phonological representations. If this is the case, we would expect the naming times for the Same Onset and Rhyming manipulations to be longer than for the standard Rapid Object Naming version of the task.

Word Length Manipulation.

In addition to the Phonological Similarity manipulation, we also manipulated the length of the names of the items to-be-named on the standard Rapid Object Naming subtest of the CTOPP (Wagner, Torgesen & Rashotte, 1999). In the first manipulation, the items to-be-named all had 2 syllable names (2-Syllable manipulation) and in the second manipulation, all of the items to-be-named had 3 syllable names (3-Syllable manipulation).

Logically, it is not reasonable to predict that increasing the length of the item to-be-named would facilitate the rapid naming process, therefore we expect that 2- and 3- syllable names will increase naming speed. We believe that this manipulation will have a more surface level influence on the rapid naming process than the Phonological Similarity manipulation, affecting the planning and execution of motor gestures in articulatory output. We expect that the longer names will increase the demand on motor planning for articulation, and the naming times will therefore be longer compared to the standard Rapid Object Naming task. This manipulation was studied as a possible contrast to the

phonological similarity manipulation in preparation for later comparisons between typical and impaired readers.

Method

Study 1

Participants

Thirty McMaster University Undergraduate students participated in the experiment. Sixteen of the participants were recruited from the Linguistics Research Methods class, and these participants received course credit. The remaining participants were recruited from an advertisement on the university website, and received $15 for their time. The participants were aged 18 to 25 years, 20 were female and 10 were male. Each participant reported English as his or her first language.

Tests and Experimental Tasks

Cognitive and Reading Tests

Gray Oral Reading Test-4 (GORT). Each participant completed the GORT-4 test. This reading test measures reading fluency and comprehension. However, for the purposes of the present study, only the reading fluency portion of the test was conducted. This test was used to assess the reading fluency level of the participants, and ensure the group can matched with other groups for this measure. Participants were instructed to read a passage aloud, as clearly and carefully as possible. The experimenter began timing at the onset of the first

word, and stopped timing at the conclusion of the final word. A standard score for reading time was calculated for each participant, representing his or her Rate Score. A standard score for reading errors (deviations from print) was calculated for each participant, representing his or her Accuracy Score. The Rate Score and Accuracy score for each participant were than combined to generate a standard Reading Fluency score.

Wechsler Abbreviated Scale of Intelligence (WASI).

Participants completed all four sub-tests in the WASI, a short and reliable measure of intelligence, appropriate for people aged 6-89. This test was conducted to ensure that all participants were in the normal range for intelligence, and assessed for any intellectual deficits. This test is composed of four subtests, measuring ***Language Processing*** and ***Spatial Reasoning***.

Vocabulary. This test required participants to orally define a series or words, read by the experimenter. Participants were given a score from 0-2 for each word, based on the accuracy of their response. A standard score was generated for each participant, based on his or her total score.

Similarities. The second subtest required participants to describe the similarities between two words named by the experimenter. Participants were given a score from 0-2, based on the accuracy of their response. A standard score was generated for each participant, based on his or her total score.

Both language subtests administered measure language processing through oral language tasks. The subtests were administered with the

Vocabulary test first and Similarities second. Combining the standard score for the Vocabulary and Similarities subtests generated a total standard score for each participant on the Language Processing Subtests.

Block Design. This test involved participants physically manipulating blocks to match given patterns. Participants were shown a series of pictures, each with a geometric design, and were instructed to use a set of blocks to replicate the design in the picture. Participants were given a score from 0-7 for each design, based on the accuracy and speed with which they completed the design. A standard score was generated for each participant, based on his or her total score.

Matrix Reasoning. This was the final subtest. It required that participants identify a pattern in a set of visual objects, and select the object that best completes the pattern. Participants were given a score of 1 if they selected the correct object, and a score of 0 if they did not. A standard score was generated for each participant, based on his or her total score.

Both of the spatial reasoning subtests administered measure spatial reasoning through visual manipulation tasks. Block Design was administered first and Matrix Reasoning second. Combining the standard score for the Block Design and Matrix Reasoning subtests generated a total standard score for each participant on the Spatial Reasoning Subtests.

Standard Rapid Naming Task.

Each participant completed the Rapid Letter Naming, Rapid Digit Naming and Rapid Object Naming subtests of the Comprehensive Test of Phonological Processing (CTOPP). All objects to-be-named on this task are monosyllabic, except for one ("pencil") Participants went over an example of each of the objects to be named for the Rapid Object Naming subset; to ensure that they would use the correct name once testing began. Participants were presented with a grid of 6 repeating items to be named (either letters, numbers or objects, depending on the version) randomly arranged in 4 rows of 9. Each item appeared 6 times throughout the grid. Participants were instructed to begin with the item in the upper left hand corner, and name each item sequentially, as quickly as possible. Naming time was recorded, from the onset of naming of the first item to the completion of the final item. These times were used as measures of Standard Naming Time.

Rapid Naming Manipulations.

Each participant completed both manipulated versions of the standard Rapid Object Naming task. The participants were given the same instructions as for the CTOPP Rapid Naming versions, and the objects to be named were reviewed prior to testing. The two manipulated RAN versions are described below:

Phonological Similarity. Participants were presented with RAN stimuli, similar to the Rapid Object Naming subtest of the CTOPP, however each of the

objects to-be-named were phonologically similar. Each grid consisted of 4 objects, randomly arranged into 4 rows of 9 items. Each item appeared 9 times. For the first manipulation, each of the objects to-be-named had the same, or similar (CV) onset (Same Onset Manipulation). For the second manipulation, each of objects to-be-named had the same (VC) rime (Rhyming Manipulation). To control for possible effects of vowel or consonant type, two versions of the Same Onset and Rhyming manipulations were used for testing (Form A and Form B), with different CV (onset) or VC (rime) combinations on each form. The two sets of Rhyming object names were: hat, bat, cat, rat (Form A) and hair, bear, chair, pear (Form B). The two sets of Same Onset object names were: boat, bowl, bone, bow (Form A) and bed, bench, bell, bed (Form B).

Word Length. Participants were presented with RAN stimuli, similar to the Rapid Object Naming subtest of the CTOPP, however each of the objects to-be-named differed by the number of syllables. Each grid consisted of 4 objects, randomly arranged into 4 rows of 9 items. Each item appeared 9 times. For the first manipulation, each of the objects to-be-named had a disyllabic name, and for the second manipulation, each of the objects to-be-named had a trisyllabic name. Each participant was presented with each the 2-syllable and 3-syllable versions of the RAN task. The 2-Syllable object names were: flower, balloon, apple and guitar. The 3-Syllable object names were: computer, banana, octopus and umbrella.

Design and Procedure

The design for the RAN experiment was within-subjects. After giving informed consent, participants completed the psychometric tests of cognitive functioning and reading as well as the different experimental versions of the rapid naming task, all in one individual session lasting about 1.5 hours. The tasks were administered in the following fixed order: (1) The complete WASI test (Wechsler, 1999), (2) standard Rapid Naming tasks (Rapid Object, Digit and Letter Naming subtests) taken from the CTOPP (full name of CTOPP in parenthesis) test, (3) manipulated versions of the Rapid Object Naming subtest, manipulated for Phonological Similarity and Word Length, and (4) the reading fluency portion of GORT-4 . All participants received the same stimulus order for each task. Half of the participants were tested with Form A of the Same Onset and Rhyming manipulations, and half Form B.

Results

GORT-4 and WASI

A summary of the performance of the typical reading Undergraduate students on the standardized tests of Reading Fluency Language Processing and Spatial Reasoning scores is displayed in Table 1.

Test	Measure	Mean	SD	Max.	Min.
GORT-4	Reading Fluency	12.83	2.12	16	8
WASI	Language Processing	111.07	11.48	140	86
WASI	Spatial Reasoning	111.07	7.14	126	96

Table 1. Descriptive statistics (mean, standard deviation, maximum and minimum values) for typical reading level Undergraduate students on the GORT-4 and WASI standardized tests.

Rapid Naming Manipulations

Phonological Similarity. The comparisons involving phonological similarity of objects are presented in Figure 1. The ANOVA on the effects of the phonological similarity manipulations indicated a significant main effect of phonological similarity, $F_{2,29} = 47.81$, $p < .0001$.

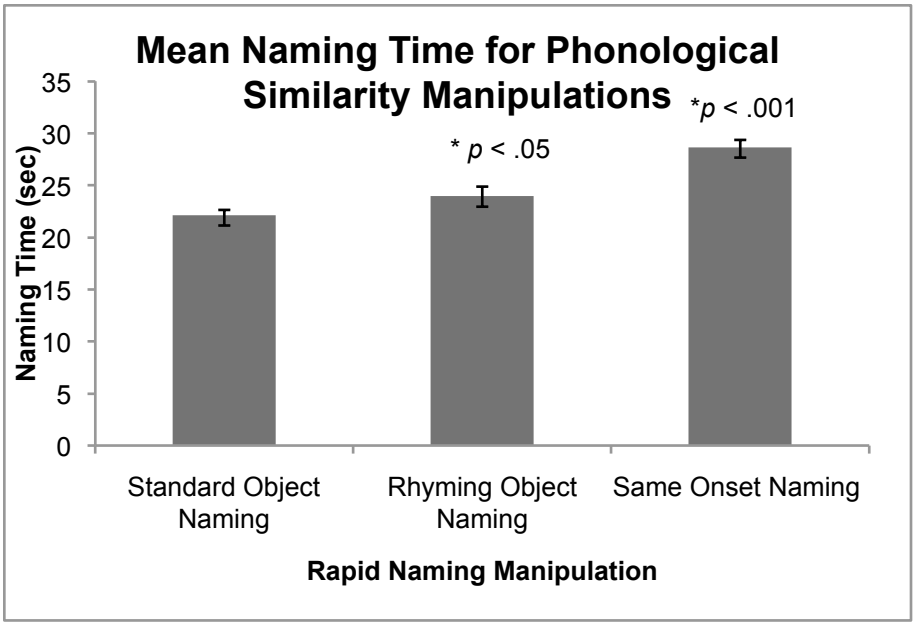

Figure 1. Mean naming time (in seconds) for typical-reading level university undergraduates, as a function of phonological similarity of the objects to be named.

To analyze the individual effects of the Same-Onset and Rhyming Object Manipulations, planned pairwise comparisons were carried out between the two manipulated conditions compared to the standard object naming task using paired t-tests. Figure 1 displays the results of the planned pairwise comparisons. The results of this analysis revealed two significant pairwise differences; the rhyming objects (M = 23.94 s, SD = .5.09 were named significantly more slowly than the standard objects (M = 22.14 s, SD = 2.73), t_{29} = -2.64 p < .05 and the same-onset objects (M = 28.67, SD = 3.83) were named significantly more slowly than the standard objects, t_{29} = -11.13 p < .0001.

Word Length. The word-length results are shown in Figure 2. A repeated measures ANOVA showed a significant main effect of word length, $F_{2,29} = 26.32$, $p < .0001$.

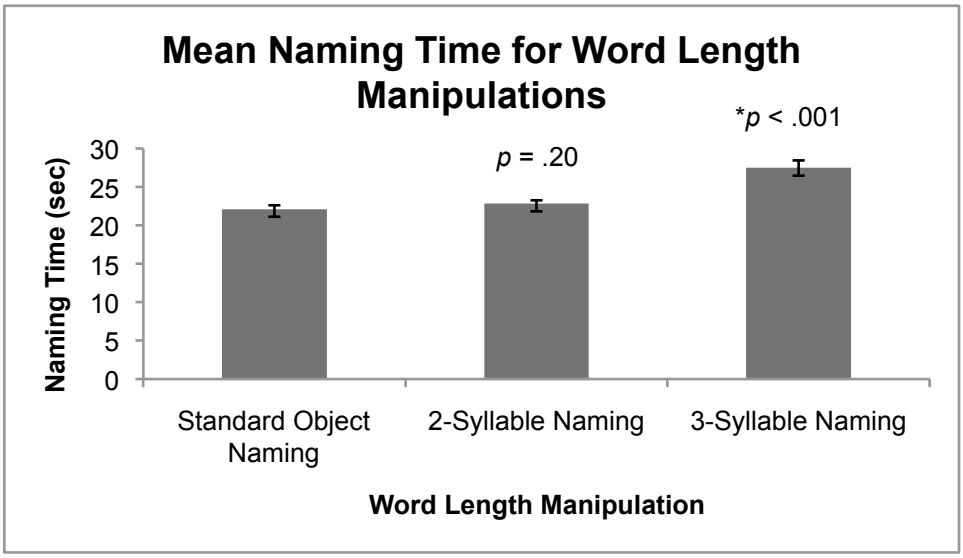

Figure 2. Mean naming time (in seconds) for typical-reading level university undergraduates, as a function of word length of the objects to be named.

To analyze the individual effect of the Two-Syllable and Three-Syllable Object Manipulations, planned pairwise comparisons were carried out using paired t-tests. Figure 2 displays the results of the planned pairwise comparisons. The results of this analysis revealed 1 significant pairwise comparison; objects with three-syllable names (M = 27.49 s, SD = 5.39) were named significantly more slowly than the objects in the standard object naming task, $t_{29} = -5.93$ $p < .0001$. There was no significant difference between naming times for two-syllable objects (M = 22.84 s, SD = 2.40) and the objects in the standard object naming task, $t_{29} = -1.30$ $p = .20$.

Discussion

The results of Study 1 revealed significant main effects of phonological similarity and word length on naming performance in the Rapid Object Naming task, in good readers. Specifically, the typical-reading-level undergraduate students in this study named the Rhyming, Same Onset and 3-Syllable Manipulations significantly more slowly than the objects in the Standard Object Naming task. Based on the present results, two influences on naming speed can be identified: phonological similarity and word length, in typical readers.

The goal of the present study was to explore the cognitive processes that influence the Rapid Naming task in order to provide a better understanding of the relationship between rapid naming performance and reading ability. Having identified two manipulations that influence rapid naming performance, exploring how the cognitive demands of the task are changed by the manipulations will provide insight into the cognitive processes contributing to rapid naming performance.

Phonological Similarity

The Phonological Similarity manipulation slowed the rapid naming speed of the typical-reading level university undergraduates. Based on these results, it seems that, in good readers, phonological similarity impairs the rapid and continuous updating of phonological representations, which slows naming time. These results suggest that similarity of phonological representations creates a competition effect during speech planning, and it becomes more difficult to

update phonological representations for naming if they have more phonological overlap. These findings are consistent with the findings of O'Seaghdha and Dell (1992), who found that a phonologically related prime inhibited participants reading a target word (both through increased naming time and increased number of segments from the prime being inserted in the target.) O'Seaghdha and Dell argue that even one discrepant phoneme between words with shared phonemes creates competition for the activation of that phoneme, and slows encoding. The present findings demonstrate that this competition effect occurs during the Rapid Naming task, when the items-to-be named have shared phonemes.

This assumed competition effect appears to be especially strong when the phonological similarity is at the word onset, as we saw significantly longer naming times for the same-onset objects than the rhyming objects. This finding that the word onset is particularly susceptible to the competition effects is in line with speech planning research, which reports that English word-onset consonants are particularly error-prone (Shattuck-Hufnagel, 1987). It seems that syllable onset provides important information for speech planning, so sources of compeition or demand on speech planning are escpecially influential at syllable onset position. The present data supports the hypothesis that syllable-internal information is accessed during speech planning, and the phonological similarity interferes with this process during the Rapid Naming task.

Word Length

As expected, the results of the Word Length Manipulation revealed that, for typical readers, objects with 3-Syllable names were named significantly more slowly than the objects in the standard object naming task. Multisyllabic words increase the demand on the speech planning and execution system, as there is a more complex phonological representation and increased number of motor gestures. When this demand is great enough (i.e. there are three syllables), rapid naming performance is slowed down. It seems that two-syllable words do not provide a sufficient demand on motor planning to influence performance. Together, the significant influence of the Same Onset, Rhyming and 3-Syllable manipulations on naming performance indicates an important role of the quality and complexity of phonological representations for speech planning during the rapid naming task**.**

Study 2

Method

Participants

Due to time limitations of the school year, only a small sample was recruited for the present study. The data collected will be considered pilot data and we intend to continue recruiting from this population and testing for this study when school resumes in September 2011.

Ten High school students were recruited from Parkview Secondary School. The participants were recruited from a reading remediation program offered by the school. All of the students in the program have been previously identified as having a reading delay. The students were recruited with a letter and permission form sent home to their parents or guardians. The students ranged in age from 14 to 16 years and all students reported English as their first language. Three male and 6 females participated. Students were rewarded with a $10.00 gift card to Tim Horton's for their time.

One participant had exceptionally low scores on all of the Rapid Naming manipulations, and was therefore considered and outlier and excluded from data analyses. Additionally, one other participant scored exceptionally low on the Standard Object Naming task only and this data point was considered an outlier. Due to the small sample size, two analyses were conducted, one including this outlier score, and one excluding it.

Materials and Procedures

All of tests used in Study 1 were also used in Study 2, using the same procedure. Appropriate adjustments were made to the starting points used, to account for the age and performance level of the high school students.

After obtaining a signed permission from a parent or guardian of the participant, the experimenter explained the procedure to the student and verbal assent was obtained, if the student wished to participate. Participation was divided into two sessions of one hour each with a one-day break in between each session. In the

first session, participants completed the entire WASI and in the second session the Rapid Naming and GORT tests, in the same order as in Study 1. Once again, half of the participants completed Form A, and half completed Form B, for both the Same Onset and Rhyming manipulations.

Results

GORT-4 and WASI

A summary of the performance of the typical reading Undergraduate students on the standardized tests of Reading Fluency Language Processing and Spatial Reasoning scores is displayed in Table 1.

Test	Measure	Mean	SD	Max.	Min.
GORT-4	Reading Fluency	1.89	1.69	6	1
WASI	Language Processing	68.9	13.2	92	55
WASI	Spatial Processing	75.8	9.77	89	60

Table 1. Descriptive statistics (mean, standard deviation, maximum and minimum) values for poor reading high school students on the GORT-4 and WASI standardized tests.

Rapid Naming Manipulations

The analyses for Study 2 were conducted twice, once including an extreme outlier in the standard object naming condition and once excluding this outlier data point.

Phonological Similarity. The results of the phonological similarity manipulation are shown in Figures 3 and 4. The repeated measures ANOVA including the outlier data point revealed a significant main effect of phonological similarity, $F_{2,8} = 11.47$, $p < .001$. The repeated measures ANOVA excluding the outlier data point also reveals a significant main effect of manipulation type, $F_{2,7} = 35.00$, $p < .0001$.

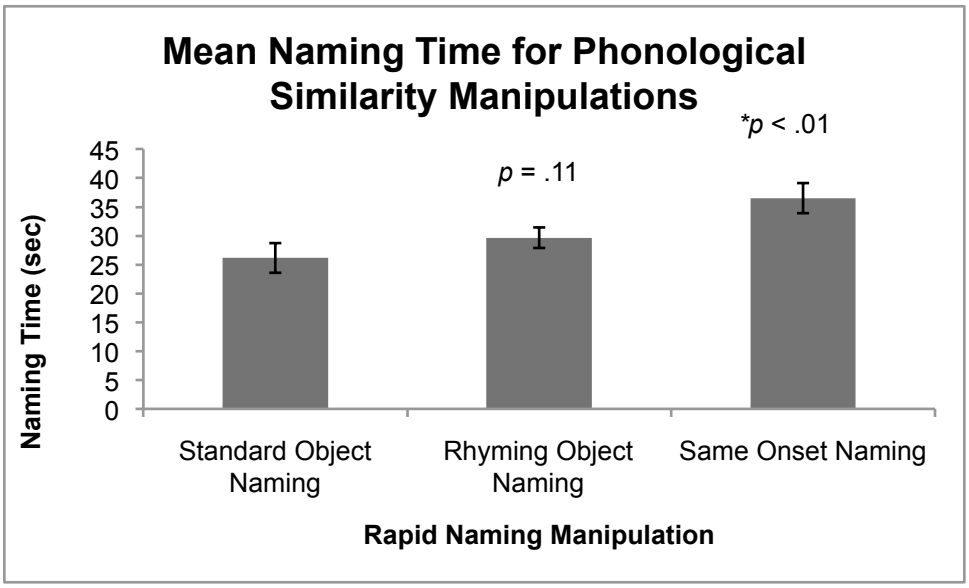

Figure 3. Mean naming time (in seconds) for poor reading high school students, as a function of the phonological similarity of the objects to be named (Standard Object Naming outlier included).

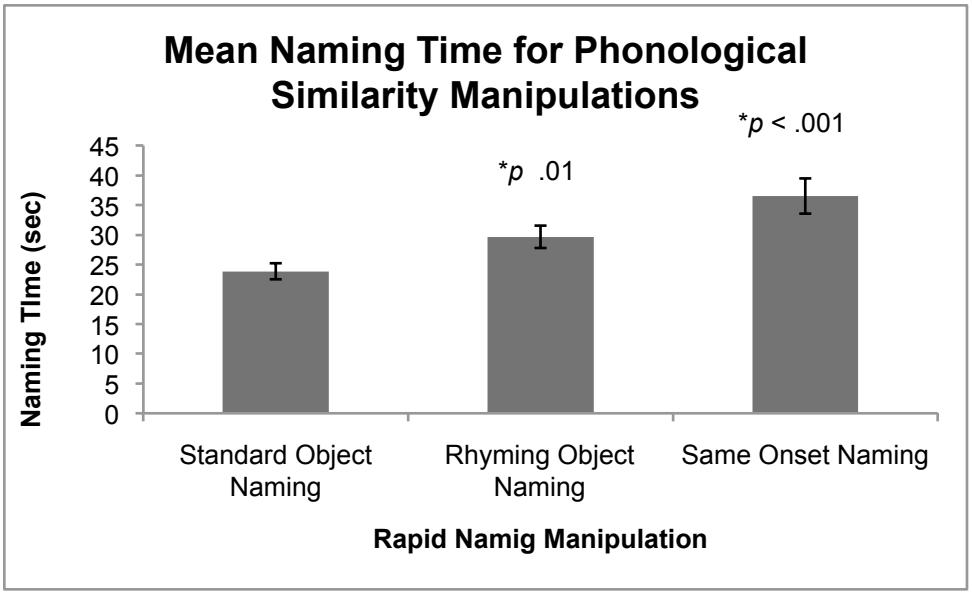

Figure 4. Mean naming time (in seconds) for poor reading high school students, as a function of the phonological similarity of the objects to be named (Standard Object Naming outlier excluded).

As in Study 1, planned pairwise comparisons were carried out using paired t-tests to analyze the individual effect of the Same-Onset and Rhyming Object Manipulations. The planned pairwise comparisons including the outlier data point reveal that the objects in the same onset manipulations (M = 46.52 s, SD = 7.83) was named significantly more slowly than the standard task (M = 26.16 s, SD = 7.72), $t_8 = -3.62$, $p < .01$. Naming time for the rhyming manipulation (M = 29.96s, SD = 5.36), however, was not significantly different than the standard task, $t_8 = 1,80$, $p = .11$. Additionally, a post-hoc comparison reveals that the same onset manipulation was named significantly more slowly than the rhyming manipulation, $t_8 = -4.13$, $p < .01$.

Planned pairwise comparisons excluding the outlier naming time in the standard object naming condition reveal that the same onset object naming times (M = 36.65 s, SD = 8.36) were significantly longer than the standard object naming times (M = 23.87 s, SD = 3.83), $t_7 = -7.30$, $p < .001$. Additionally, with the outlier excluded, the objects in the rhyming manipulation (M = 29.0 s, SD = 5.31) was named significantly more slowly than those in the standard object naming task, $t_7 = -4.52$, $p < .01$. Once again, a post hoc comparison revealed that the same onset manipulation were named significantly more slowly than those in the rhyming manipulation, $t_7 = -4.13$, $p < .01$.

Word Length. The data for the word-length manipulation are displayed in Figures 5 and 6. The repeated measures ANOVA including the outlier data point reveals that the main effect of word length on naming time was not significant, $F_{2,8} = 2.56$, $p = .11$. However, the repeated measures ANOVA excluding the outlier data point reveals a significant main effect of the Word Length manipulation, $F_{2,7} = 4.96$, $p < .05$.

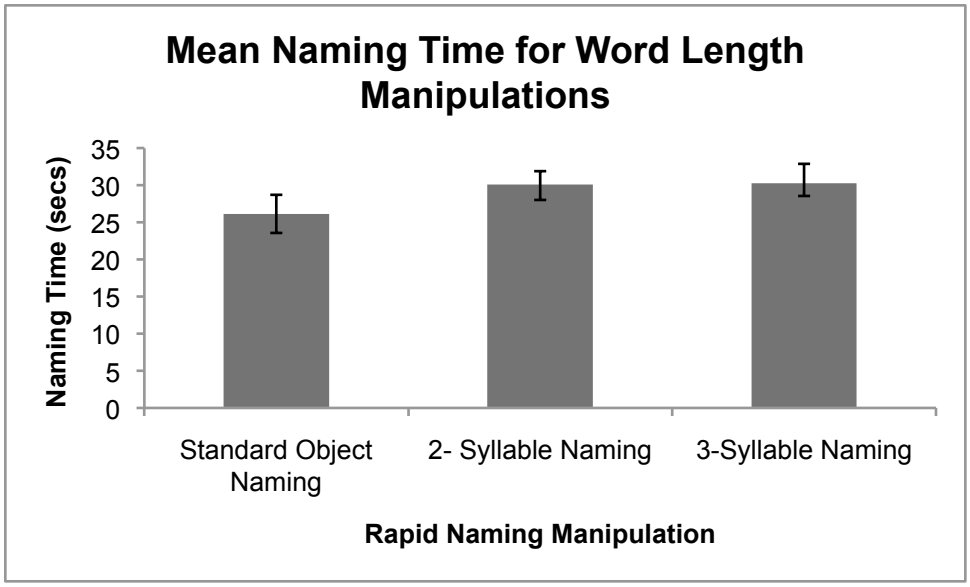

Figure 5. Mean naming time (in seconds) for poor reading high school students as a function of the word length of the objects to be named (Standard Object Naming outlier included).

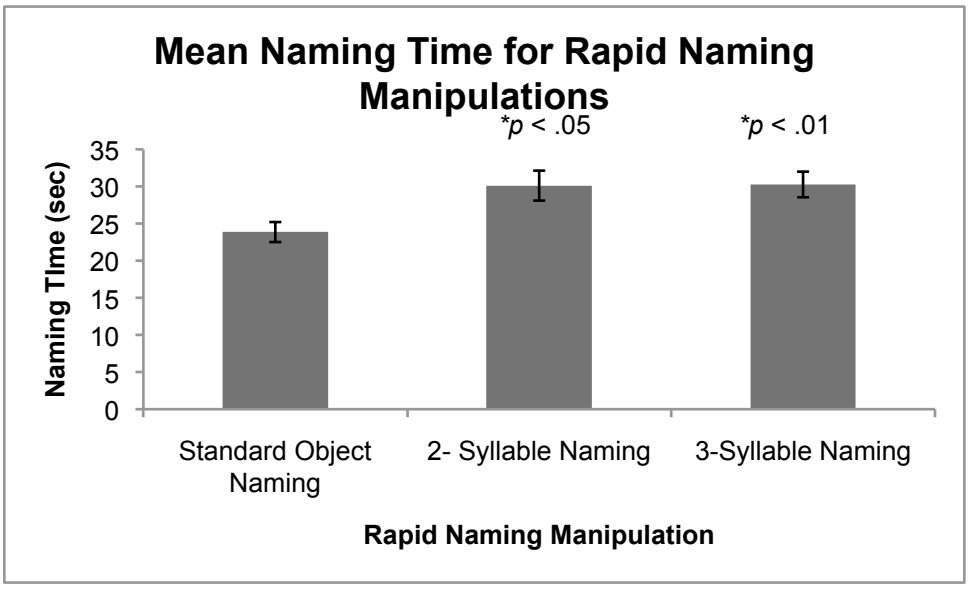

Figure 6 Mean naming time (in seconds) for poor reading students as a function of word length of the items to be named (Standard Object Naming outlier excluded).

Planned pairwise comparisons were carried out to examine the differences in naming times for the Standard Object Naming task, the 2-Syllable Manipulation and the 3-Syllable Manipulation, excluding the outlier data point. This analysis revealed that the 3-Syllable objects (M = 29.50 s, SE = 4.90) were named significantly more slowly than the objects in the standard object naming task, $t_7 = -4.48$, $p < 01$. The 2-Syllable objects (M = 30.13 s, SE = 6.29) were also named significantly more slowly than the objects in the standard object naming task, $t_7 = -2.42$, $p < .05$.

Discussion

As in Study 1, the results of Study 2 revealed a significant main effect of the phonological naming manipulations. This suggests that the naming performance of individuals with reading difficulty is influenced similarly to that of typical readers by phonological similarity and word length. With all outlier data excluded, the reading impaired high school students in Study 2 displayed significantly slower naming times for each manipulation (Same Onset, Rhyming, 2-Syllable and 3-Syllable). The present results indicate that the influences on naming speed identified for typical readers have a similar influence on naming speed in poor readers.

Phonological Similarity

The results of Study 2 reveal that, once again, phonological similarity of items to-be-named slowed down rapid naming performance. It seems that, in poor readers, phonological similarity is creating the same competition for

updating of phonological representations that was demonstrated in typical readers. Additionally, the same-onset objects were named significantly more slowly than the rhyming objects, suggesting that activation of phonological information for speech planning is the same in good and poor readers. It seems that both groups access the syllable-internal information in the same way.

Although the present data reveal that phonological similarity creates competition for rapid updating of phonological representations during the naming task within groups of both good readers and poor readers, considerable age differences between the groups tested prevent accurate comparisons between the groups. In order to explore the differential effects of the phonological similarity manipulation in good and poor readers, further data collection is planned: an age-matched control group of typical-reading-level high school students will be tested on the same manipulations as in the present study. Although Phonological Similarity slowed naming speeds for each group, there is evidence to suggest that the magnitude of the effect of phonological similarity may be different.

Evidence from short-term memory experiments suggests that poor readers perform differently than typical readers on tasks containing phonologically similar words. For example, when presented with lists of phonologically similar words, typical readers show decreased accuracy of immediate serial recall as compared to lists of phonologically dissimilar words, a phenomenon called the Phonological Similarity Effect (e.g. Gathercole, et al. 2005). However, evidence suggests that poor readers do not always show this

effect, and recall accuracy is the same for both phonologically similar and dissimilar lists (e.g. Hulme 1984; Sipe & Engle, 1986). This finding suggests that similarity of phonological representations creates competition in typical readers, making accurate recall of phonologically similar words difficult. This competition, however, is not always seen in poor reading individuals, indicating that these individuals are not processing phonological information in a typical way.

Although in the present study, both typical and poor readers demonstrated an impairment of naming ability for phonologically similar words, a comparison between more appropriately matched groups might reveal differential effects of phonological similarity between good and poor readers. Specifically, as demonstrated in short-term memory tasks, competition for phonologically similar words may be reduced in poor readers, and naming times for the difference between the standard Rapid Object Naming task and the Phonological Similarity Manipulations would be smaller for this group than for typical readers. Such a finding would provide evidence for difficulty in the rapid and continuous updating of phonological representations in poor readers.

Word Length. The poor readers in Study 2 revealed a similar pattern of results to the good readers on the Word Length Manipulation**,** as the 2- and 3-syllable objects were named significantly more slowly than the objects in the standard object naming task. Once again, when there is increased demand on planning and execution of motor gestures, naming performance is slowed down. In the group of poor readers, this demand appeared to become influential already when there were 2-syllables, suggesting that poor readers may be more

susceptible to naming impairments due to complexity of the motor gestures for speech planning.

As with the Phonological Similarity manipulation, a comparison of a more appropriately matched group of good and poor readers could reveal differential group effects of the Word Length manipulation on naming speed. Studies using word repetition provide evidence to suggest that poor readers have difficulty with multisyllabic words. For example, Brady, et al. (1989) tested third-grade average and below average readers on a word repetition task with monosyllabic and multisyllabic words. Brady, et al (1989) report that there were no differences in repetition performance between average and below average readers for monosyllabic words. However, below average readers performed significantly worse than average readers when repeating multisyllabic words. Moreover, poor readers had particular difficulty pronouncing multisyllabic words with a difficult phonetic sequence. Brady, et al. (1989) argue that their findings reflect differences in encoding accuracy between good and poor readers. A comparison between good and poor readers on the Word Length manipulation of the present study may provide further evidence for impairments of phonological encoding accuracy in poor readers.

General Discussion

Phonological Similarity and Word Length Effects

The goal of the present study was to identify some of the cognitive processes that underlie the Rapid Naming task, in order to better understand the

relationship between rapid naming performance and reading ability. The results of the present study reveal two influences on naming time for the Rapid Naming task: phonological similarity and word length. Phonological similarity of both the onsets and rimes of the objects to-be-named, as well as multi-syllabic names made naming times significantly longer compared to the Standard Object Naming task, for both typical-reading university students and poor-reading high school students. These effects will be considered in turn below.

Phonological Similarity. Based on the results for the Phonological Similarity manipulation, it seems that in good as well as poor readers, phonological similarity of the items to-be-named creates competition in the rapid naming task. We believe that this competition occurs at the level of updating the phonological representations, and that such competition may also contribute to reading difficulty. This finding supports the hypothesis of Brady, et al. (1989), who believe that reading difficulty occurs at an abstract level of phonological encoding.

What is not entirely clear, however, is whether or not the competition created by the phonological similarity is influencing retrieval speed or articulation in the Rapid Naming task. There remains an unresolved discrepancy in the literature as to whether speed of processing or articulation rate underlie Rapid Naming times. However, investigating pause time and articulation time separately during rapid naming may provide insight into this debate. Hulme et al. (1999) showed that pause time and articulation duration are independent of one another, with pause time reflecting the retrieval of phonological representations.

Additionally, Neuhaus, Foorman, Francis and Carlson (2001) report that pause durations were differentially related to reading ability, whereas articulation times were unrelated to reading in first and second grade students. In future research, the pause times and articulation times of the present study should be examined. If the phonological similarity manipulation is, in fact, creating competition at the level of phonological representations, it is expected that pause times will be influenced, but not articulation times.

Word Length. The results of the word length manipulation demonstrate that for good and poor readers, naming time is increased when the items to-be-named are multisyllabic. This indicates that an increased demand on planning and executing the motor gestures for speech production lengthens naming times. The fact that 2-syllable words resulted in slowing the poor reading group, and not the typical reading group suggests that poor readers may be more susceptible to the complexity of the phonological representation and motor gestures during speech planning.

Once again, examining the pause times and articulation times for the manipulations in the present study will provide further insight into whether multi-syllabic names create increased demands, reflected in slower naming rates, for articulatory planning or articulation itself.

Poor Reading Group Considerations

As stated previously, the group of poor reading high school students tested in the present study was used as a pilot group, and further testing will

need to be conducted on this population. There are special considerations that must be accounted for when investigating this group and interpreting the data collected.

Age of Participants. The most consistent rapid naming deficits in poor readers have been reported in groups of children, and evidence for an association between naming performance and reading ability in adolescents or adults is mixed. The participants in the present study were all between the ages of 14 and 16 years. Therefore, the strength of the relationship between naming ability and reading may have weakened, if naming speed deficits do not persist into adolescence. Korhonen (1995) investigated the persistence of rapid naming difficulties in poor readers from childhood to early adulthood. Results of this study showed that the children who displayed naming difficulties when originally tested in the third grade, were still significantly slower at the naming task when tested in early adulthood. Thus, the findings of Korhonen (1995) provide evidence for the persistence of naming difficulties into adolescence. The results of Korhonen (1995) have limitations to consider before generalizations can be made, as they were based on a small sample size, and participants were selected based on their naming impairments. Continued testing of the students from the secondary school of Study 2 will provide further insight into the relationship between rapid naming performance and reading ability in poor-reading adolescents.

Profiles of Learning Difficulties. Students attending the secondary school of Study 2 have all been diagnosed with some kind of learning impairment, however the individual profiles of different student vary greatly.

These variations must be taken into consideration, as there is evidence that the reading deficits experienced by learning disabled groups can have different characteristics based on the specific impairments of the individual.

Everatt, Weeks and Brooks (2007) explored the profiles of groups of children from a variety of Special Educational Needs (SEN) groups, including those with diagnoses of dyslexia, mild learning difficulties (MLD), specific language difficulties (SLD), dyspraxia, attention deficit (hyperactivity) disorder (AD(H)D) and emotional/behavioral difficulties (EBD). The performance of children from these SEN groups was compared to performance of a control group of typically developing children on measures of literacy, phonological and verbal skills, non-verbal ability, problem behavior scales and cognitive interference. Results of this study revealed that all SEN groups displayed evidence for reading impairment, however they diverged on various other measures of performance (Everatt, et al., 2007). Specifically, in addition to reading impairments the dyslexic, MLD and SLD groups showed impairments of phonological awareness, rapid naming and verbal span. Conversely, the dyspraxic, AD(H)D and EBD groups, who also showed reading impairments, were not consistently worse on the measures of phonological awareness, rapid naming or verbal span.

Similarly, Ghelami, Sidhu, Jain and Tannock (2004) report that children with attention/behavioral problems perform at a similar level to typically developing controls on a colour naming task. Everatt, et al (2007) argue that this differentiation indicates that an alternate causal pathway is needed to explain

poor reading in the groups of dyspraxic, AD(H)D and EBD. The results of the Everatt, et al. (2007) study indicate that children who display reading difficulties may have different profiles of strengths and weaknesses. Specifically, and of particular relevance to the present study, the reading difficulties of children with AD(H)D, or emotional or behavioral problems may not be associated with the same phonological or naming difficulties that generally characterize a poor reader. The present sample or poor readers may have reading difficulties due to one or a combination of the learning difficulties investigated in the Everatt, et al. (2007) study. Therefore to accurately characterize the influences of the manipulations on naming speed on this population, the profiles of the students must be examined. Additionally, further testing on this population will allow for a more detailed examination of naming difficulties on various learning disabled groups.

Conclusion and Future Directions

Both similarity of onset and rime and word length were identified as significantly increasing naming times on the Rapid Naming task in the present study, for both good and poor readers. We believe that the impairment of naming performance created by phonological similarity reflects competition during the rapid updating of phonological representations. Additionally, we believe that the increased naming time for multisyllabic words results from the increased demand on planning motor gestures for speech production. We will be continuing our research in September 2011, collecting more data from the group of poor reading high school students at the school of Study 2. Additionally, we will be collecting

data from a group of age-matched controls, so that comparisons can be made between groups, to potentially identify differential effects of our manipulations on good and poor readers. This research will also contribute to an understanding of the persistence of Rapid Naming difficulties into adolescence. Future research should also separately explore the pause times and articulation times for the Phonological Similarity and Word Length Manipulations, in order to help determine whether competition created by these manipulations influences pre-articulatory processes, or articulation itself.

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