Effects of Phonological Analysis, Rapid Naming, and Visual Search Performance on 5TH Grade Reading in Japanese

Maya Shiho Kobayashi*2 Charles W. Haynes*3
Pamela E. Hook*3 Paul Macaruso*4

ABSTRACT: This study examined the relative validity of phonological analysis (mora deletion, sound matching), rapid automatized naming (RAN), and visual search (cross out speed and accuracy) abilities for predicting fluent text reading and reading comprehension within typically developing Japanese 5th graders (39 in all). Analogous abilities have been identified as important predictors of reading skills in alphabetic languages like English. Given the differences between English and Japanese orthography, it was hypothesized that unique patterns of relationships would be obtained for children reading Japanese. The results demonstrate that mora deletion contributes significantly to speed of oral reading. When mora deletion was excluded from the regression model, RAN (number, hiragana, kanji) also explained variance in oral reading speed. Furthermore, visual search speed predicts accuracy of oral reading. When there is no influence of visual search speed in the regression model, sound matching and kanji RAN are also significantly associated with oral reading accuracy. General knowledge influenced reading comprehension. Based on our previous studies on reading of Japanese kindergartners and first graders, the findings suggest that the predictive power of these measures varies depending on the nature of the reading task and stage of development.

Key Words: Japanese reading fluency, phonological analysis, Rapid Automatized Naming (RAN), visual search

1. INTRODUCTION

There has been increased interest in reading fluency in recent years because of a growing recognition of its importance in reading comprehension. Fluency requires not only the ability to recognize words automatically, but also to apply appropriate rhythm, intonation, and phrasing to the text so that attention can be allocated to comprehension (Meyer, Felton, 1999). According to the results of the Programme for International Student Assessment (PISA), which is an internationally standardized assessment administered to 15-year-olds school children in approximately 30 to 40 participating countries, Japan’s performance in reading decreased significantly from 2000 to 2003 (OECD, 2000, 2003). There is no clear explanation for this result; however, considering the fact that Japan maintained high scores in mathematics and science in the same years, it appears that the number of Japanese adolescents who struggle with reading is increasing.

The current study examined relationships between reading skills and selected cognitive-linguistic predictors including phonological analysis (mora deletion, sound matching), rapid automatized naming (RAN), and visual search (cross out speed and accuracy) in Japanese fifth graders. Teachers and researchers are concerned with the early detection of children who are at risk for reading disabilities and also looking for the early prediction of children’s later reading achievement; therefore, establishing reliable and valid assessment tools is of critical importance.
A large body of research has demonstrated that phonological analysis, RAN, and visual search abilities are important for the acquisition of word recognition, fluency, and reading comprehension in alphabetic languages such as English (Badian, 1994, 1995, 1998; Cornwall, 1992; Cunningham, Perry, Stanovich, et al., 2002; Meyer, Wood, Hart, et al., 1998; Scarborough, 1998). English is an alphabetic language based on grapheme-phoneme relationships, whereas Japanese orthographies are comprised of two syllabaries – hiragana and katakana, and a system of morphosyllabic symbols (“kanji”). In our previous studies, in Japanese kindergartners, hiragana RAN and number RAN best predicted reading accuracy and speed. In our Japanese first graders, however, kanji RAN and hiragana RAN were the best predictors of oral reading speed, mora deletion best predicted oral reading accuracy, and kanji RAN, mora deletion, and phonological memory best predicted reading comprehension (Kobayashi, Haynes, Macaruso, et al., 2006; Kobayashi, Kato, Haynes, et al., 2005). Additionally, deficits in phonological awareness, speeded naming, and visual/orthographic abilities successfully differentiated Chinese dyslexic readers from typically achieving readers (Ho, Chan, Tsang, et al., 2002). We hope that our current study will add to our general understanding of the cognitive-linguistic skills that underlie the ability to read Japanese and also provide additional support for developing tasks that facilitate early detection of children who may struggle with learning to read.

1.1 PHONOLOGICAL ANALYSIS

Phonological analysis, or phonological awareness, refers to the ability to detect and manipulate explicitly and segmentally the sounds in one’s oral language. This ability is found to be critical for the efficient decoding of printed words and the ability to develop correspondences between sounds and letters when spelling or reading English (Badian, 1995; Cornwall, 1992). While phonological analysis is a strong predictor of early reading ability, it has been suggested that the relationship is reciprocal: the ability to read also facilitates phonological analysis (e.g., Bowey, Francis, 1991). Phonological analysis skills can be assessed by comparing and contrasting the sounds of words for rhyme and alliteration, blending and segmenting into syllables, and manipulating sounds at the phoneme level (Adams, 1990). Previous studies have found that kindergarten tasks involving manipulation of phonemes were some of the strongest predictors of later reading development (Wagner, Torgesen, 1987). In Japan, past studies found a strong relationship between phonological analysis and acquisition of reading skills (Amano, 1970, 1988, 1989; Hara, 1998; Oishi, 1998). Mann (1986) reported that Japanese first graders were found to be aware of syllables and less aware of phonemes in comparison to most American first graders who were found to be aware of both syllables and phonemes. Moreover, Japanese children’s syllable (mora) and phoneme counting ability significantly predicted speed and errors in oral reading of hiragana words. Endo (1991) reported that six-year-old Japanese kindergarten children develop phoneme awareness and their phoneme awareness performance contributes significantly to reading ability. In our more recent studies, a mora deletion task, which required a child to hear a real word, repeat the word, delete one specified mora, and say the reconstructed word, did not predict kindergartners’ reading speed and accuracy (Kobayashi et al., 2003; Kobayashi et al., 2005). However, in first graders, mora deletion predicted reading accuracy and reading comprehension (reading comprehension was not administered for kindergartners in our previous study). These results indicate that the first grade text which was relatively complex and consisted of hiragana, katakana, and kanji characters required higher phonological analysis skills than the kindergarten text which was relatively simple and mainly consisted of hiragana characters. We expect that the more complex text for fifth graders will require higher phonological analysis skills. This study examines the contributions to reading performance of two phonological analysis tasks 1) mora deletion from our previous study, and 2) sound matching which requires phoneme recognition.

1.2 RAPID AUTOMATIZED NAMING (RAN)

Rapid automatized naming (RAN), as well as phonological analysis, has been extensively proven to be related to reading performance in English (Badian, 2005; Manis, Seidenberg, Doi, 1999). RAN tasks require one to name a series of five to six randomly repeated stimuli (colors, number, letter, common objects) as quickly as possible, (Denckla, 1972; Denckla, Rudel, 1974). RAN and reading tap similar underlying processes; they require recognition and identification of symbols, retrieval of a pronunciation for each symbol and articulation of it, and then careful rapid scanning to the next symbol (Miller, C., Miller, S., Bloom, et al., 2006; Stringer, Toplak, Stanovich, 2004; Wolf, Bowers, 1999). Functional magnetic resonance imaging studies have also indicated that RAN tasks require the same neural network as is involved in reading (Misra, Katzir, Wolf, et al., 2004). However, reasons why the association between inefficient RAN performance and weak reading abilities occur are not fully understood. There have been numerous hypotheses regarding this association. RAN may require automaticity of underlying component skills, may represent general difficulty in speed of processing, and/or could
reflect poor coordination of the various underlying processes (Korhonen, 1995; Snyder, Downey, 1997; Wolf, Bowers, 1999, 2000).

RAN’s predictive power has been replicated in many studies (Denckla, Cutting, 1999; Schatschneider, Carlson, Francis, et al., 2002; Wolf, Bowers, 1999, Wolf, O’Rourke, Gidney, et al., 2002). However, not all RAN tasks are equally powerful in prediction of reading. Letter and number RAN are robust predictors of reading ability, while object and color RAN are less predictive (Denckla, Cutting, 1999). In addition, letter and digit forms of the RAN are strong predictors of single word reading, but not of reading comprehension (Meyer et al., 1998). It has also been suggested that when typically developing children’s reading fluency is high such as in grade 3 or 4, RAN may contribute only minimally to their reading performance (McBride-Chang, Manis, 1996).

In a study of Japanese 6-year-olds, the speed of rapid alternating stimulus naming for objects and numbers significantly correlated with identification of 6 hiragana characters (Kaneko, Uno, Haruhara, 2004). In our previous studies, we constructed four RAN tasks including objects (chair, fish, pencil, star, key, ship), numbers (2, 3, 4, 5, 7, 8), hiragana (た,に, を, い, の, と), and kanji (金, 人, 上, 手, 月, 11). The results indicated that hiragana and number RAN predicted oral reading speed and accuracy in kindergarten, and hiragana RAN and kanji RAN predicted reading speed in first graders (Kobayashi et al., 2005; Kobayashi et al., 2003). Moreover, kanji RAN significantly contributed variance in reading comprehension in first graders. In the current study, we wish to explore the relationship of RAN performance to reading in a more advanced level of grade school reading in Japanese.

1.3 VISUAL PROCESSING

As previously noted, there is well-established evidence that phonological analysis and RAN play critical roles in reading acquisition (Manis, Doi, Bhadha, 2000; Miller et al., 2006), but there is growing evidence that various visual and orthographic tasks also add significant variance to reading (Badian, 2005; Swanson, Trainin, Nechoechea, et al., 2003). Badian defined visual-orthographic skills as the ability to recognize the correct orientation of letters and numbers (Badian, 2005). Bowers and Wolf (1993) suggested that orthographic processing skills can be assessed with visual matching tasks which require careful scanning and comparing of symbols and symbol sequences. Badian (1994) reported that a visual-orthographic task in kindergarten, which required the child to scan for matching letters and word-like groups of letters, was the best predictor of reading and spelling in first graders when compared to phonological awareness and serial naming speed. In longitudinal studies, visual symbol matching was found to significantly predict reading comprehension, reading vocabulary, and spelling (Badian, 1995). Orthographic pattern recognition task performance has also been related to word-level decoding (Bourassa, Treiman, 2003).

In our previous studies of Japanese first graders, visual search speed significantly correlated with speed of oral reading and reading comprehension. In a study of Chinese, a lexical decision task requiring children to distinguish between correctly oriented radicals and those that are reversed did not differentiate good readers and poor readers among third graders (Penney, Leung, Chan, et al., 2005). Katzir, Wolf, O’Brien, et al. (2006) have pointed out that contributions of visual or orthographic processing skills to reading fluency and comprehension are still under-investigated. In addition, it has been suggested that intact phonological processing skills alone is not sufficient enough to fully explain development of fluent reading and comprehension (Juel, Griffith, Gough, 1986). In the present study, we employ a visual search task to investigate the hypothesis that visual search processes may predict later Japanese grade school reading.

1.4 GENERAL KNOWLEDGE

We previously stressed “fluency” as a key to lead children to reading comprehension; however, fluent decoding alone is not sufficient for reading comprehension (Hirsch, 2003). General knowledge, which includes prior or background knowledge about the topic, cultural understanding, and world and vocabulary knowledge, is important to deepen reading comprehension (Hirsch, 2003; McNamara, Kintsch, Songer, et al., 1996). The “fourth grade slump” refers to the finding that a child’s reading achievement starts to fall off in around fourth grade even though he or she appears to be making adequate progress in basic decoding skills (Chall, Jacobs, 2003). According to Chall’s reading stage theory, in the beginning of Stage 3 (grades fourth to eighth), children need to use basic decoding skill as a tool for learning new words and ideas beyond their own language and their knowledge of the world (Chall, 1983). Japanese national curriculum standards for fifth and sixth grader reading target the enhancement of the student’s ability to identify and choose reading materials independently and to comprehend the content in order to obtain new information, deepen their knowledge, and construct further thinking (Ministry of Education, Culture, Sports, Science and Technology; MEXT, 2003). Even though a reader can successfully decode a text, if he or she fails to make rapid connections between new and previously leaned content or prior knowledge, adequate reading comprehension might
not be achieved. Therefore, the current study will explore the contribution of general knowledge to the comprehension of fifth grade text.

Investigations of relationships between cognitive-linguistic factors and developing reading abilities in Japanese are under-researched. The lack of research on non-alphabetic orthographies limits our accurate understanding of both typical and impaired reading function and it is critical to know whether a particular model applies across different orthographies or to just one type of orthography. The ultimate goal of the present study is to contribute to the current understanding of the underlying structures of different aspects of Japanese reading by examining cognitive-linguistic measures which have already been found to be related to English reading. In this study, we sought to investigate following questions;

1) What are the relationships between selected cognitive linguistics measures (phonological analysis, RAN, visual search) and types of reading performance in Japanese 5th graders?
2) What are the relative contributions of each of these cognitive linguistic measures to reading performance in Japanese 5th graders?

Based on the previous studies in English and on our studies of Japanese reading among kindergartners and first graders, we hypothesized that phonological analysis, RAN, and visual search would each predict unique variance in fifth grade reading performance in Japanese. Additionally, we expected that the contribution of each to reading performance would differ from patterns found in Japanese kindergartners and first graders. We hypothesized that, because fifth grade text is more complex and comprises more kanji characters, in addition to phonological analysis and RAN’s contribution, visual search would contribute more toward prediction of reading accuracy and speed. In addition, phonological analysis performance at the phoneme level would contribute more to reading accuracy than mora deletion, and general knowledge would contribute to reading comprehension.

2. METHOD

2.1 PARTICIPANTS

The participants were 39 (23 boys, 16 girls) monolingual typically developing Japanese speakers aged 10 to 11 years in a small suburban elementary school in Chiba prefecture. Mean age at the time of testing was 11.24 years of age (SD=3.3 months), with a range of 130 to 141 months. There were no participants diagnosed with ADHD or any other developmental disabilities.

2.2 MEASURES

The following measures were included in this study.

2.2.1 Phonological Analysis

There were two types of tasks administered in this study, mora deletion and sound matching.

(1) Mora Deletion

The Japanese mora deletion test was based on the Elision subtest of the Comprehensive Test of Phonological Processing (CTOPP) (Wagner, Torgesen, Rashotte, 1999), and was the same task used in our previous studies (Kobayashi et al., 2003; Kobayashi et al., 2005). There were three practice items followed by twenty test items. Children hear a real word, repeat the word, delete one specified mora, and say the reconstructed word. The number of morae for test items increased from four to eight. If a child was not able to perform the practice item, the test was not given. Testing was discontinued when a child missed three items in a row. Scores are reported as the number correct.

(2) Sound Matching Tasks

First Sound: This task was taken from Endo’s (1991) study. The student is asked to look at 1 target and 3 testing pictures. The examiner points to each picture and says a word corresponding to each picture. Then the student is asked to point a picture which starts with the same sound (phoneme) as the target picture’s name. The original task had two testing choices, but this task was modified to offer three testing choices to decrease the influence of children’s guessing (see Appendix A). There were four practice items followed by 10 test items. For all testing items, no feedback was given by the examiner and testing. Scores are reported as the number correct.

Last Sound: In this task, children were asked to identify which word out of three words has the first mora ending with the same sound (phoneme) as the first mora of a target word orally presented by the examiner. The same procedure from the First Sound task was employed for this task (see Appendix B). There were four practice items followed by 10 test items. Scores are reported as the number correct.

2.2.2 Rapid Automatized Naming

This task requires the child to name as quickly as possible six symbols repeated six times in random order and displayed on a chart in a 4 × 9 format. Two RAN tasks (objects, number) were taken from the CTOPP (Wagner et al. 1999). Two additional RAN tasks (hiragana, kanji), constructed to simulate the format of RAN tests on the CTOPP, were taken from our previous studies (Kobayashi et al., 2003; Kobayashi et al., 2005). The examiner says to the
participant, "I want you to say the names of all of these objects (or letters) as fast as you can. Try not to skip any. Ready? Begin." The examiner starts a stopwatch timing as soon as the participant says the name of the first object (or letter) and stop timing when the name of the last item is said. The scores were reported as the time taken in seconds to complete the chart.

2.2.3 Visual Search

The short version of the cross-out subtest of the Woodcock Johnson - Revised Cognitive Battery (WJ-R) (Woodcock, Johnson, 1989) was included as a measure of visual processing. This task requires the child to look at a target symbol on the left side of the page, and search for (circle) five identical symbols included randomly in a row of 19 stimuli. There were two practice rows and 11 test rows. Scores recorded included the time taken in seconds to complete the task and the error score which consisted of the total number of missed targets and circled incorrect items.

2.2.4 General Knowledge

The WISC-III Information subtest (Azuma, Ueno, Fujita, et al., 1998) was administered to each child to obtain measures of general knowledge. The examiner asks a question regarding factual knowledge and historically famous people and the child is required to produce the answer. Raw scores were analyzed.

2.2.5 Reading Speed and Accuracy

The child was asked to read aloud a short fifth grade level passage comprised of hiragana, katakana, and kanji. The score for passage reading speed was time in seconds taken to read the passage. Error scores were defined as the number of morae read incorrectly.

2.2.6 Reading Comprehension

Reading comprehension was tested by a standardized reading comprehension measure (Okamoto, Muraishi, 1983). The Kuder-Richardson reliability coefficient was 0.93. Validity, confirmed by good-poor analysis, was $Z=3.662$. Twelve minutes were given to children to complete this test. There were 28 multiple choice questions on seven short passages including narratives (4) and expository texts (3). Children were required to read silently and circle the answers. The score was the number of correct items.

2.3 PROCEDURES

The reading comprehension test was group-administered to participants in their classrooms by classroom teachers. The rest of the measures were administered individually in a quiet room in their school, generally in two twenty minutes sessions by the examiner. The sequence of tests was fixed in an order that avoided consecutive administration of similar tasks.

3. RESULTS

Means, standard deviations, and ranges for all variables are given in Table 1 for the total sample.

3.1 CORRELATIONS

*Question 1) What are the relationships between selected cognitive linguistics measures (phonological analysis, RAN, visual search) and types of reading performance in Japanese 5th graders?*

Intercorrelations among scores on phonological analysis, RAN, and visual search, and the three reading measures were examined using Pearson correlation analyses, controlling for children's age (see Table 2). Children's age
was partialed out in order to examine the relationships between variables after controlling for the age differences (in months) among the participants in our sample. The negative correlations of RAN, visual search (speed and accuracy), and oral reading (speed and accuracy) with other variables reflect the fact that higher scores indicate lower performance.

Mora deletion and all the RAN tasks except for object RAN correlated with oral reading speed. Sound matching-last, kanji RAN, and visual search speed correlated with oral reading accuracy. WISC-III Information and sound matching-last correlated with reading comprehension. All the reading performance measurements correlated with each other.

3.2 REGRESSION ANALYSIS

Question 2) What are the relative contributions of each cognitive linguistic measure (phonological analysis, RAN, visual search) to reading performance for Japanese 5th graders?

Hierarchical regression analyses were performed to determine the unique variance contributed to reading measures by each cognitive linguistic measure which showed significant correlations with reading performance. Each of the predictors was entered into the model individually at the second step after participants’ age and

Table 2. Correlations between measures, partialing out age (Total=39)

<table>
<thead>
<tr>
<th>Variable</th>
<th>1 WISC</th>
<th>2 MD</th>
<th>3 SM_F</th>
<th>4 SM_L</th>
<th>5 RAN_O</th>
<th>6 RAN_N</th>
<th>7 RAN_H</th>
<th>8 RAN_K</th>
<th>9 VS_S</th>
<th>10 VS_A</th>
<th>11 OR_S</th>
<th>12 OR_A</th>
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<td>4. Sound Matching (Last Sound)</td>
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<td>5. Visual Search (Speed)</td>
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Note: WISC=WISC-III Information, MD=mora deletion, SM_F=sound matching (first sound), SM_L=sound matching (last sound), RAN_O=Object RAN, RAN_N=Number RAN, RAN_H=Hiragana RAN, RAN_K=Kanji RAN, VS_S=visual search (speed), VS_A=visual search (accuracy), OR_S=oral reading speed, OR_A=oral reading accuracy

Table 3. Hierarchical regressions of variables separately predicting reading performance

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<th>( \Delta R^2 )</th>
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<th>( R )</th>
<th>( R^2 )</th>
<th>( \Delta R^2 )</th>
<th>( \Delta F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Matching Last</td>
<td>.49</td>
<td>.24</td>
<td>.18</td>
<td>4.64*</td>
</tr>
<tr>
<td>Kanji RAN</td>
<td>.49</td>
<td>.24</td>
<td>.10</td>
<td>4.72*</td>
</tr>
<tr>
<td>Visual Search Speed</td>
<td>.47</td>
<td>.22</td>
<td>.15</td>
<td>3.46*</td>
</tr>
</tbody>
</table>

* \( p<.05 \); ** \( p<.01 \); *** \( p<.001 \)

Note: Each of the predictors was entered into the model individually at the second step after participants’ age and WISC-III Information were entered into the model at the first step.
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WISC-III Information were entered into the model at the first step to control for the effects of these variables on reading performance. As shown in Table 3, the results demonstrate that participants’ performance on mora deletion, number RAN, hiragana RAN, and kanji RAN tasks explained variance in oral reading speed. Participants’ performance on sound matching-first and last, kanji RAN, and visual search speed were significantly associated with their performance on oral reading accuracy. Participants’ performance on sound matching last did not significantly explain variance in reading comprehension beyond the participants’ age and WISC-III Information variables.

Stepwise regressions were conducted to determine the best predictors of the reading measures (oral reading speed and accuracy, reading comprehension) among the processing variables (mora deletion, sound matching first and last, object RAN, number RAN, hiragana RAN, kanji RAN, visual search speed and accuracy) (see Table 4). Mora deletion remained significant in explaining variance in oral reading speed. For oral reading accuracy, the only significant predictor was visual search speed. There was no single processing variable found to predict reading comprehension. When WISC Information was included in the model, however, its contribution to the prediction of reading comprehension was significant.

Reading fluency is one of several critical components necessary for reading comprehension in English. Because there was no single processing variable that predicted reading comprehension, stepwise regressions were conducted to determine which component of oral reading performance (reading accuracy and/or reading speed) contributed to fifth grade reading comprehension. Oral reading speed was the only significant contributor to reading comprehension (see Table 5).

### 4. DISCUSSION

In this study, a group of Japanese fifth graders were administered a battery of tests that included phonological analysis (mora deletion, sound matching first and last), four kinds of RAN (object, number, hiragana, kanji), and visual search (cross out speed and accuracy), as well as WISC Information and measures of reading comprehension and fluency. There were two major goals in this study. The first was to examine relationships between selected cognitive-linguistic skills and reading performance (oral reading speed and accuracy, reading comprehension). The second was to determine which measures best predicted fifth grade reading performance. We also examined whether a stage theory of advanced level reading acquisition that had been developed primarily from English populations also held for Japanese fifth graders.

Mora deletion, number RAN, hiragana RAN, and kanji RAN each contributed to prediction of oral reading speed independently and the measure that most effectively predicted oral reading speed was mora deletion. With respect to oral reading accuracy, sound matching last, kanji RAN, and visual search speed contributed variance independently; however, when all the dependent measures were entered into the stepwise regression, only visual search speed consistently predicted oral reading accuracy. Sound matching of the last phoneme significantly predicted reading comprehension; however, when the stepwise regression included all the dependent measures, its predictive power was canceled. When WISC-III Information was entered into the stepwise regression along with other processing variables (mora deletion, sound matching first and last, object RAN, number RAN, hiragana RAN, kanji RAN, visual search speed and accuracy) (see Table 4). Mora deletion remained significant in explaining variance in oral reading speed. For oral reading accuracy, the only significant predictor was visual search speed. There was no single processing variable found to predict reading comprehension. When WISC Information was included in the model, however, its contribution to the prediction of reading comprehension was significant.

Reading fluency is one of several critical components necessary for reading comprehension in English. Because there was no single processing variable that predicted reading comprehension, stepwise regressions were conducted to determine which component of oral reading performance (reading accuracy and/or reading speed) contributed to fifth grade reading comprehension. Oral reading speed was the only significant contributor to reading comprehension (see Table 5).

### Table 4. Summary of stepwise multiple regression analyses for reading performance

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>$R$</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
<th>$\Delta F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mora Deletion</td>
<td>.48</td>
<td>.23</td>
<td>.23</td>
<td>11.24**</td>
</tr>
</tbody>
</table>

* $p<.05$; ** $p<.01$; *** $p<.001$  
Note: These stepwise regressions included all the processing variables (mora deletion, sound matching first and last, object RAN, number RAN, hiragana RAN, kanji RAN, visual search speed and accuracy).

### Table 5. Summary of stepwise multiple regression analyses for reading comprehension

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>$R$</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
<th>$\Delta F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral Reading Speed</td>
<td>.64</td>
<td>.40</td>
<td>.39</td>
<td>25.03***</td>
</tr>
</tbody>
</table>

* $p<.05$; ** $p<.01$; *** $p<.001$  
Note: This stepwise regression included oral reading speed and accuracy.
measures, its contribution towards prediction of reading comprehension was the largest among all the variables.

Mora deletion correlated with all the RAN tasks except for object RAN. This result is largely consistent with findings reported in studies of alphabetic reading, and supports the view that phonological analysis and RAN tap into some of the same underlying processing abilities (e.g., retrieval and production of phonological information) (Miller et al., 2006). Unlike some studies of alphabetic reading that have indicated weak relationships between phonological analysis and RAN (Wolf, Bowers, 1999; Swanson et al., 2003), this study's correlations between a phonological analysis measure (mora deletion) and RAN speeds were relatively high ($r = -.52$ to $-.57$, $p < .001$) and lend support to Miller et al.'s (2006) conclusions.

Despite the above correlations, hierarchical regression analyses demonstrated that both phonological analysis (mora deletion) and RAN also contributed independent variance to oral reading speed. This finding suggests that certain underlying processing differences in these tasks may be significant in predicting text-level fluency (e.g., recognition of visual stimuli, association of visual with phonological symbols, manipulation of phonological information, speed). The independent contributions of phonological analysis and rapid naming to prediction of reading performance is consistent with a double deficit hypothesis as proposed by Wolf et al. (2002). Further support for this view is underscored by the finding that functional magnetic resonance imaging shows basic differences in underlying processes required by phonological analysis and RAN measures (Misra et al., 2004).

Within the limitations of a cross sectional analysis, several interesting questions arise. The data from our previous study of first grade beginning readers (Kobayashi et al., 2006) suggest some complex developmental similarities and differences when compared with results of our current study of fifth graders. In first graders, high correlations were found between mora deletion and all measures of reading (speed, accuracy and comprehension). In the current study of fifth graders, mora deletion correlated only with oral reading speed. In addition, performance on all of the RAN tasks (object, number, hiragana, kanji) in first grade correlated with oral reading speed and comprehension, while symbol-based RAN tasks in fifth grade correlated significantly with oral reading speed but not with comprehension. There were also differences in correlations between mora deletion and RAN tasks. In first graders, object and kanji RAN correlated with mora deletion, while in fifth graders the three symbol-based RAN tasks correlated strongly with mora deletion. The following questions arise:

1) Why is a task of phonological analysis (mora deletion) more highly correlated with RAN performance in the fifth grade than in the first grade?
2) Why does mora deletion continue to have a significant correlation with reading speed in grade five?
3) Why are there correlations between reading comprehension and performance on cognitive linguistic tasks of mora deletion and RAN in the first grade data, but not in the fifth?
4) In the fifth grade data, why is there no significant correlation between reading comprehension and RAN performance, given the strong correlation between RAN performance and oral reading speed and between oral reading speed and reading comprehension?

Potential answers to these questions may lie in developmental differences in the processing requirements of reading and comprehending text at the first versus fifth grade. One explanation for the first question as to why phonological analysis (mora deletion) is more highly correlated with RAN performance in the fifth grade than in the first grade, may lie in the different processes tapped by the mora deletion task for older children. At the fifth grade level, children typically manipulate stimuli of increased length (up to eight morae); in order to be successful at this level, it is possible that children may need to be able to rapidly coordinate phonological memory, retrieval and orthographic (kana) visualization processes. As noted earlier, RAN makes similar requirements for coordination of various underlying processes (Korhonen, 1995; Snyder, Downey, 1997; Wolf, Bowers, 1999, 2000).

Our second question, as to why mora deletion continues to have a significant correlation to reading speed in grade five may also be related to the discussion above which emphasizes differing requirements of the mora deletion task at different grade levels. The text used in our study of first graders consisted of 5% kanji characters whereas the fifth grade text in the current study contained 23% kanji characters. Kanji characters require the retrieval of correct pronunciations. The increased in the number of kanji characters coupled with increased syntactic and semantic complexity of text at this stage seems to place more demands on working memory, perhaps in a similar manner to the mora deletion task. This may explain why the phonological analysis task best predicted rapid decoding of the fifth grade connected text in Japanese.

The third question, as to why there are correlations between reading comprehension and performance on cognitive linguistic tasks of mora deletion and RAN in the
first grade data, but not in the fifth, may be related to developmental differences in the processing requirements of first versus fifth grade reading. Early elementary text contains familiar concepts and decoding is sufficient for comprehension; the emphasis is primarily on learning to map sounds onto hiragana and katakana characters, which have mostly regular symbol-sound correspondences. By fifth grade the focus in reading comprehension tasks is on gaining new information and assumes adequate word identification. Our findings support Manis, Seidenberg, and Doi’s hypothesis that phonological analysis is more related to the learning of systematic letter-sound correspondences, whereas the RAN task involves routinized, automatic symbol-sound associations (1990). Both of these processes are largely automatic in the typically developing fifth grade reader. As Schatschneider et al. (2002) suggested, RAN appears to best predict the elementary stage of word recognition, and RAN’s contribution to reading performance may lessen when children’s reading fluency becomes higher such as in grade 3 or 4 (McBride-Chang, Manis, 1996).

Our fourth question was why there is no significant correlation between reading comprehension and RAN performance in the fifth grade, given the strong correlation between RAN performance and oral reading speed and between oral reading speed and reading comprehension. There does not appear to be a simple explanation for these findings. They suggest, however, that the specific aspects of RAN that correlate with oral reading speed may involve processes that are distinct from those tapped in the relationship between reading speed and comprehension. Current research is emphasizing the complexity of the reading task and supports the view that “in reading fluency, the whole is more than its parts” (p.77, Katzir et al., 2006). From our perspective, this would certainly hold true for reading comprehension as well.

Our previous study showed that mora deletion contributed to prediction of the first grader’s oral reading accuracy (Kobayashi et al., 2005); however, in this study, visual search speed consistently contributed variance to oral reading accuracy even after accounting for the influence of all other processing variables. Thirty nine percent of the total oral reading errors (hiragana errors 50%, katakana errors 11%) came from incorrect decoding of kanji characters; this suggests that the ability to accurately recognize and recall visually complex configurations partially influences fifth graders’ reading accuracy. Poor visual search speed performance may be related to poor orthographic memory and eventually leads to failure to retrieve accurate pronunciations for each character. In our previous studies, in kindergartners, visual search speed did not correlate with any aspect of reading performance, however, in first graders, it correlated moderately with reading speed and reading comprehension (Kobayashi et al., 2003; Kobayashi et al., 2005). As children’s mastery level of reading advances, visual or orthographic processing may become more important in explaining more advanced reading in Japanese. This study’s findings suggest the value of a visual search task for explaining accuracy of reading. Incorporation of this task in assessment and prediction studies may prove very useful for older children.

Whereas mora deletion explained variance in oral reading speed, sound matching last only explained variance in reading comprehension. These findings suggest that even though both mora deletion and sound matching tasks are phonological analysis measures, they may tap into different cognitive and linguistic requirements. This is also demonstrated in the comparatively weak correlation between these two tasks. Mora deletion involves manipulation of speech sounds at the mora level while sound matching last requires recognition of final phonemes in words. The metalinguistic skills underlying manipulation at the mora level is consistently found to be important across three decades of research, but phoneme identification in Japanese has been less investigated. Lack of predictive power of sound matching first can be explained by previous findings that phoneme awareness of the initial sound of a word is easier than that of the final sound (Spector, 1995). The mean score for sound matching first (m=8.56, SD=2.17) was significantly higher than the mean for sound matching last (m=6.85, SD=3.42), p=0.003. Thus, sound matching first was a relatively easy task, which did not tap into underlying cognitive linguistic processes required to perform any of the reading outcome measures.

Even though, there was no single cognitive-linguistic measure that significantly predicted fifth grade reading comprehension, our results indicate that general knowledge plays an important role in this area. The WISC-III Information subtest reflects the richness of the child’s background knowledge. Our results indicate that successful reading comprehension of fifth grade materials requires not only fluent decoding skills, but also general knowledge which appears to enhance basic comprehension and leave room for making connections between the new information and previously learned knowledge, drawing inferences, and thinking over implications (Hirsch, 2003). Moreover, the findings from this study have implications for intervention; instruction and practice in fluency by training for phonological analysis, rapid decoding, and recognition of orthography need to be accompanied by instruction and practice in general knowledge.
In conclusion, our research offered an insight into underlying cognitive-linguistic skills required by Japanese fifth grade reading. This study indicates that Japanese fifth graders learning to speak and read Japanese also develop some of cognitive-linguistic skills found to be important for reading in English. However, performance on phonological analysis, RAN, visual search, and general knowledge only partially explained accuracy, fluency, and comprehension of reading. It has been suggested that different cognitive-linguistic skills tap different aspects of linguistic processing and, therefore, relate differently to reading (Ramus, 2003). Therefore, there will be more cognitive-linguistic skills related to explaining reading performance in Japanese, and these skills are expected to vary according to grade level, children’s reading experience, and components of reading assessed. As noted, some of our analyses are based on cross sectional data; a longitudinal study would help clarify the predictive power of these skills as children advance through grade school. Further research will also provide us with a theoretical framework and refined understanding of cognitive-linguistic skills of reading in Japanese and may suggest guidance for practical remediation approaches.

ACKNOWLEDGMENTS

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Stringer, R., Toplak, M. E., Stanovich, K. E. Differential relationships between RAN performance, behavior ratings, and executive function measures: Searching for


**APPENDIX A** Stimulus Words Used for Sound Matching First (Underlined letters indicate target sounds)

| 1. | kyo-u | kya-ku | nya-n-ko | syo-ku-jji |
| 2. | syo-ku-jji | sya-ko | nya-n-ko | hyo-u-shi |
| 3. | kyo-u-dai | kya-be-tsu | syo-u-ka-ki | cha-wan |
| 4. | syo-u-ka-ki | myo-u-jji | sya-be-ru | cha-wan |
| 5. | kya-ku | sya-ko | kyu | ryu |
| 6. | kó-ka | ká-ki | na-shi | so-ra |
| 7. | só-ra | sei | ho-shi | na-shi |
| 8. | kó-ya | ká-ki | na-ru | ta-ne |
| 9. | só-ri | ho-shi | sa-ru | ta-ne |
| 10. | ká-ki | ku-ma | ta-ne | ru-bi |

**APPENDIX B** Stimulus Words Used for Sound Matching Last (Underlined letters indicate target sounds)

| 1. | kyo-u | kya-ku | nya-n-ko | syo-ku-jji |
| 2. | syo-ku-jji | sya-ko | nya-n-ko | hyo-u-shi |
| 3. | kyo-u-dai | kya-be-tsu | syo-u-ka-ki | cha-wan |
| 4. | syo-u-ka-ki | myo-u-jji | sya-be-ru | cha-wan |
| 5. | kya-ku | sya-ko | kyu | ryu |
| 6. | kó-ka | ká-ki | na-shi | so-ra |
| 7. | só-ra | sei | ho-shi | na-shi |
| 8. | kó-ya | ká-ki | ta-ne | mo-mo |
| 9. | só-ri | ho-shi | sa-ru | ta-ne |
| 10. | ká-ki | ku-ma | ta-ne | ru-bi |

**小学5年生における音韻認識，Rapid Naming，視覚探索課題の読み能力への影響**

小林マヤ（志帆） Charles W. HAYNES Pamela E. HOOK Paul MACARUSO


大石, 1998)，日本語の音頭分析能力を測定する標準化された検査は依然として存在しない。今回の調査では以前の調査で使用したモーラ削除課題と、モーラ操作よりも難易度が高いとされる音素認識課題（遠藤, 1991）を使用した。

RAN は、不規則かつ連続的に列記された 5 〜 7 種類のオブジェクト、文字、数字などをできるだけ早く読み上げるという課題である（Denckla, 1972; Denckla, Rudel, 1974)。英語圏で、読み障害児の RAN 課題を行うスピーキャップが健常児よりも著しく低いことが報告されて以来、RAN と読みパフォーマンスとの関連研究が多数報告されている（Denckla, Cutting, 1999; Schatschneider, Carlson, Francis, et al., 2002; Wolf, Bowers, 1999, Wolf, O'Rourke, Gidney, et al., 2002)。そして欧米では RAN 課題が音頭分析課題と並び、読み障害児（ディスレキシア）のスクリーニング・テストとして広く使用されている。我々の調査では、オブジェクト（椅子、魚、鉛筆、星、船）、数字（2, 3, 4, 5, 7, 8）、ひらがな（た、に、を、い、の、と）、漢字（金、人、上、手、月、山）の 4 種類の RAN 課題を使用した。


効果的な読解を達成するためには、“流暢性”（fluency）に加え、“一般的知識”が重要な役割を果たすことが報告されている（Hirsch, 2003)。一般的知識とは、主題にまつわる背景知識、文化に対する造詣、世界観や価値を含める（Hirsch, 2003; McNamara, Kintsch, Songer, et al., 1996)。文字を音頭化するという基本的なスキルをマスターしたとしても、その読者流の一般的知識が乏しいものだった場合、読書から入手しようとした新しい知識と自分が既にある知識との関連付けに失敗し、結局は効果的な読解が達成できないと考えられている（Hirsch, 2003)。今回の調査では、基本的な読解スキルをマスターしたレベルにある小学 5 年生を対象にしているため、認知言語的能力に加えて一般的知識の読解に対する影響を検証する。

我々のこれまでの調査により、英語圏において読み