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The Effectiveness of Early Screening and Intervention for Children at Risk of Reading Underachievement

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The purpose of this study was to develop a screening test for children at risk of reading underachievement and to investigate the effectiveness of the early-stage intervention program. In the first part of the study, we recruited 155 elementary first grade students for a screening test. Phonological deletion, digit naming, object naming, and sound-letter correspondence knowledge of a screening test, all assessed at the beginning of the school year, predicted the reading ability at the end of the school year. In the second part of the study, we analyzed the difference in the reading ability between fourteen children who participated in the intervention program and eighteen non-participating children. Reading ability was assessed by evaluating word recognition, oral reading fluency, reading comprehension, and pseudo-word recognition. The reading ability of intervention group improved more compared to control group, and the difference between two groups accentuated over time. However, final analysis conducted in November revealed that two groups did not differ significantly in oral reading fluency. This suggests that, unlike word recognition and comprehension, fluency might not dramatically improve in a short period.

Keywords: reading underachievement, early screening, intervention, phonological awareness, RAN, orthography

Introduction

Reading is the most essential part of the basic education, and it is directly related to career and leisure activities in adulthood. Previous studies show that children differ significantly in their reading ability, and this discrepancy` could become larger depending on the type of school education (O'Connor, 2000). For example, Badian (2001) suggested that only 13% of children with poor reading skill at first grade earned average-level reading skill at fourth grade. Thus, early identification of children with greater risk of reading failure is very important. Furthermore, it is essential to intervene efficiently and appropriately at the earliest stage. Previous research reveals that 82% of children at risk of reading failure could become successful readers with early intervention (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996). As described above, if early intervention is the best way to tackle the reading problem of children, then it is also important to identify children most at risk of reading failure using an efficient assessment at an early stage (NICHD, 2000; Schatschneider, Francis, Carlson,

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Flectcher, & Foorman, 2004). However, tests that assess with reliable variables predict reading skills are rarely found; and so are the screening tests for at-risk children. Moreover, the efforts to perform early interventions to preemptively block the developmental pathways leading to learning underachievement are far less than enough. Thus, the goals of this research were to develop a screening test for children at risk of reading underachievement, to examine the effectiveness of the measure, and to confirm the enhancing effect of early-stage intervention program on the reading ability of children.

Researchers suggest that phonological awareness, rapid automatized naming (RAN), orthographic knowledge, and working memory predict reading underachievement (Bishop, 2003; Catts, Gillispie, Leonard, Kail, & Miller, 2002; Hammill, 2004; Holland, McIntosh, & Huffman, 2004; Lee, 2008; McCallum, Bell, Wood, Below, Choate, & McCane, 2006; Powell, Stainthorp, Staurt, Garwood, & Quinlan, 2007; Wagner et al., 1997). Previous studies revealed that letter knowledge and phonological awareness are the most critical precursors of early reading skills (Caravols, Violin, & Hulme, 2005; Lonigan, Burgess, & Anthony, 2000; Muter, Hulme, Showling, & Stevenson, 2004). Thus, these elements need to be considered when developing an early intervention for reading problems.

Many researchers agree with the importance of phonological awareness, RAN, and orthographic knowledge factors known as 'Big Three' of reading strategy (McCallum et al., 2006; Swanson, Trainin, Necoechea, & Hammil, 2003). Georgiou, Parrila, and Kirby (2006) suggested that phonological awareness, RAN, and orthographic knowledge could also be used to develop both a comprehensive measure of reading ability and therapeutic intervention.

Swanson and Siegel (2001) demonstrated that an essential problem of children with reading disabilities is working memory deficit because the 'Big Three' strategic skills described above depend on long-term memory to some extent. For example, to predict reading skills of school age children, Bishop (2003) and Bishop and League (2006) developed a screening test for preschoolers with optimal predictive variables, and performed a study to examine its validity and to maximize its predictability. Screening test composed with predictive variables such as letter identification, phonological awareness, and rapid naming were administered to 103 preschoolers during first and second trimesters. Also, reading achievement test consisted of reading comprehension, reading fluency, and word and pseudo-word recognition, was administered to the same children at the last quarter of first grade year. As a result, test consisting letter identification, phonological awareness, and rapid naming best predicted reading ability at the first year of primary school. Although the predictability of second trimester was higher but no significant differences were found between administration times. Finally, multivariate screening model was found to be economic model to effectively predict reading achievement by performing follow-up study to 79 children for four years.

The study of McCallum et al. (2006) examined the relationship between three main cognitive process factors, spelling/phonology/ RAN, visual and auditory working memory, and reading ability. Working memory significantly contributed to reading ability. These results suggest that an efficient test battery for predicting reading disorder should include working memory as well as phonological awareness, RAN, and orthographic knowledge (Bishop, 2003; Bishop & League, 2006). Thus, it is necessary to develop a screening battery that would include multiple constructs as predictors of reading disabilities and to validate the effectiveness of the measure.

Approaches to improve reading ability can be classified as bottom-up approaches, top-down approaches, and balanced approaches. Phonological awareness instruction and phonics instruction belongs to bottom-up approach (Kameenui & Simmons, 1997). Phonics instruction teaches reading skills and strategies explicitly, directly and systematically.

Systematic phonics instruction is significantly effective for kindergarten through 6th grade

children with reading underachievement. Previous researches indicated that systematic phonics instruction showed substantial and strong effect on the reading achievement of kindergarten and first-grade children in particular. In addition, the effect of phonics reading instruction seems to persist for a long time after the end of the intervention. Phonics instruction has been proved to be a very effective approach, regardless of age, the severity of reading problem, and social economic status of family (Schatschneider et al., 2004).

Muter et al. (2004) performed a yearlong reading enhancement program and effectiveness study to British first graders who are at-risk in reading. Children were to participate in a 20-minute, 6-person-group-based program emphasizing phonological awareness for 15 weeks. As a result, 44 out of 67 children (66%) showed improvement in reading skill thus excluded from at-risk group. Second intervention was performed focused on phonological awareness and phonics instruction for the 23 children who didn't show much improvement on the first trial; as a result, 16 children were no longer included in at-risk children. According to the study, it was suggested that strengthen phonics instruction emphasizing alphabet principle and knowledge, rather than performing phonics instruction alone maximizes the effect of the program. Although the effect of phonics instruction has been proved, it would be more effective to consider phonics instruction as a part of comprehensive reading program (Ehri, Nunes, Stahl, & Willows, 2001). Key factors related to reading ability should not be separated because each of the elements is a part of a single instruction process. Thus, comprehensive and intensive reading program that would integrate all primary elements would be most ideal (Stuebing, Barth, Cirino, Francis, & Flectcher, 2008).

Successful intervention targeting reading improvement would require an approach focusing on foundational reading skills. Acquisition of foundational reading skills could be achieved effectively by systematic, explicit, and direct instruction. However, depending only on phonics instruction is not sufficient to be a successful reader. Other essential reading elements should be combined to invent complete and balanced reading program (Ehri et al., 2001; Swanson et al., 2003). Thus, it is important to construct a total reading program by combining phonics instruction with other critical reading elements, such as phonemic awareness training, skills to improve verbal fluency, and strategies for improving reading comprehension, because reading ability of children is not limited to only phonics skills.

Thus, the goals of this research were twofold: (a) to develop an early screening test for children at risk of reading underachievement and to examine the ability of the measure to predict reading ability, and (b) to confirm the effectiveness of early-stage intervention program on the children's reading ability.

Study 1
The predictive ability of screening test for children at risk of reading underachievement

Methods

Participants

This study involved 181 elementary first grade students from two schools (63%), three private educational institutes (12%), five community centers (11%), and personal contacts (14%). The recruitment period was from February to March. Screening test was administered at the beginning of the school year (from March to April) and reading ability test was administered at the end of school year (November). Among 181 participants, 14 children were identified as subject of early intervention, and 12 children dropped out of the study. Among 12 children who dropped out of the study, 7 children dropped out because they attended private educational institutes that closed down, 2 children transferred to another school, and 3 children left private educational institutes for private reasons. Thus, final analysis conducted in

November used the data from 155 children. The sample consisted of 83 boys and 72 girls with mean age of 78.8 months. Written informed consent was obtained after providing subjects and their parents with a full description of the study.

Procedures

In study 1, a screening test administered to all the subjects at the beginning of the school year identified children at risk of reading failure. These children were assigned to early intervention program from May to October. Lastly, a reading ability test was administered at the end of the year to all subjects. Figure 1 describes the study procedures.

Pilot Study. Pilot study was administered on February to ten elementary students (five boys, five girls) at their schools or homes in Seoul to investigate the utility of measures, to identify possible problems with the study process, and to assess the time required to complete the assessment. A screening test administered individually required approximately 40-50 minutes per student. Reading ability test that was to be administered at the end of the year was tested preliminary on five children to evaluate suitability of test items, assess the time required, and identify possible problems with the study process. This preliminary reading ability test was administered on October to children by visiting their homes. The measure required approximately 20 minutes per student to complete.

Test Administration. Four Ph.D. students and two master's of psychology students administered the screening test. They were well trained to administer and score the test. Inter-rater reliability of .88-.94 confirmed the robustness of screening test, as the scores of all raters were consistent. Administration of the entire screening test required approximately 40-50 minutes per student. One Ph.D. student and one master's of psychology student administered reading ability test in November to all children subjected to the screening test at the beginning of the school year in their schools, community centers, or private educational institutes. Reading ability test required approximately 20-30 minutes per student to complete. Inter-rater reliability of .93-.97 confirmed the consistency of reading ability measures.

Measures

Early Screening Test. The early screening test consists of four elements: phonological awareness, RAN, orthographic knowledge, and working memory. Because there was not a standardized test for measuring phonological awareness in Korea, we developed a phonological awareness test for this study after investigating a large number of literatures on

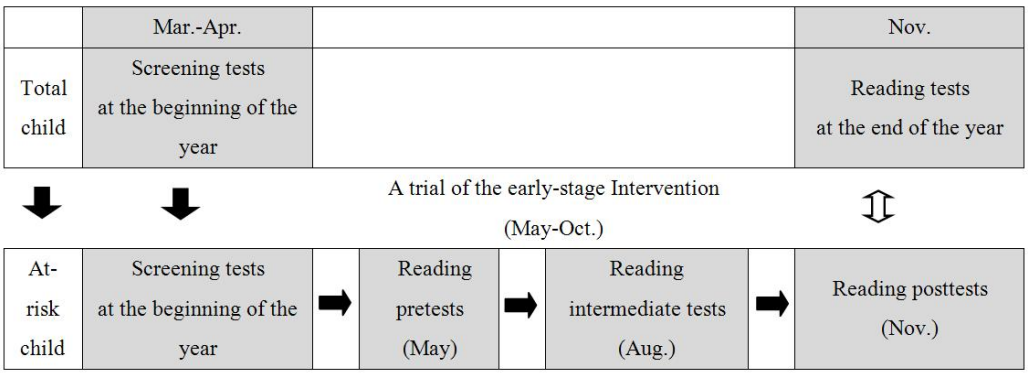

Figure 1. Study procedures

phonological awareness (Kim & Bae, 2007). Since there are no standardized tests to assess phonological awareness, the test was constructed by combining and adjusting several research results. Suggestions on comprehensive diagnosis of phonological awareness development of assessment model, types of subtests, number of test items, and methods of administration from Kim (2007) and Seok (2006) were especially helpful in this process. This study used deletion, blending, discrimination, and displacement task at the syllable and phonemes levels.

Korean version of RAN test consists of a number, letter, object, and color. It is based on RAN test originally developed by Denckla and Rudel (1976). In the case of object, 'house, eye, book, horse, ship' were chosen as a target because these words are one-syllable words in Korean. 'Two, six, seven, eight, nine' were selected for number, and 'red, blue, yellow, green, black' were selected for color as Denckla and Rudel (1976) recommended. Letters included 'ㄱ, ㄷ, ㅂ, ㅎ, ㅈ', which are most commonly used letters in Korean.

Two tests measured the orthographic knowledge. First, alphabet knowledge test assesses whether the children are aware of the name of vowel and consonant. In this study, we developed an alphabet knowledge test based on previous studies (Share, 2004; Wagner et al., 1997; Kim, 2008; Kim, 2005). This test consists of tasks that involve naming 40 vowels and consonants, such as 14 consonants, 10 vowels, 10 diphthongs, and so on. Second, sound-letter corresponding knowledge test was developed based on several previous studies (Kim, 1995). This test consists of fifteen sensible graphemes and fifteen non-sensible graphemes.

To measure working memory span, we selected a verbal task and a visuospatial task. First, visual working memory was assessed using digit span task (forward and backward) of K-WISC-III (Gwak, Park, & Kim, 2001). Second, visuospatial working memory was assessed using subtest of WAIS memory scale called a corsi block. Originally, corsi block was a commonly used measure for assessing visuospatial working memory and visuospatial ability of children with a learning problem (Berg, 2008). Full IQ scale was also used by adopting two short subtests consisting of vocabulary/block design to screen out children with significant intellectual dysfunction. This combination of subtests was selected because of their high reliabilities and high correlations with the Full WISC Scale (Stringer, Toplak, & Stanovich, 2004). IQ score was calculated only for reference; thus, it was not included in final analysis.

Reading Ability Assessment. To assess the reading ability, we administered tests related to three reading elements. Word and pseudo-word reading as well as oral reading fluency were assessed in terms of word recognition. Reading comprehension was evaluated by assessing basic reading comprehension of short sentences.

First, word recognition ability was assessed using reading 1 (recognition of letters and words), a subtest included in Basic Academic Skills Test (Park, Yoon, & Park, 1989). Pseudo-words reading test was composed of words meaningless but having the same phonological processes pattern as the words used in reading 1 task of Basic Academic Skills Test. Pseudo-word reading test was administered only once in November because we developed the test later.

Second, oral reading fluency was assessed using the reading part of Basic Academic Skills Assessment (BASA) (Kim, 2000). Third, reading comprehension was assessed using several subtests included in the Korean Institute for Special Education-Basic Academic Achievement Test (KISE-BATT). Reading test of KISE-BATT consists of subtests measuring pre-reading skills, word decoding ability, and reading comprehension. We selected reading comprehension, such as sentence completion, vocabulary selection, and sentence arrangement from among these subtests.

Data Analysis

Descriptive statistics were calculated and expressed as mean, standardized deviation (SD), range, minimum, and maximum score.

Correlational analysis was also conducted to evaluate the relationships among outcome variables. Stepwise regression analysis was used to identify the ability of variables to predict the reading ability of children. In this study, normality of the sampling distribution was validated. The variance inflation factor (VIF) ranged from 1.000 to 2.558, and the Durbin-Watson index ranged from 1.691 to 1.930 across all variables; thus, the multicollinearity problem was also excluded. All test scores were standardized. SPSS/PC Ver. 15.0 was used for statistical analysis.

Results

Descriptive Statistics

Table 1 represents the means, standard deviations, range, and subjects' minimum and maximum scores for the dependent and independent variables under investigation. In terms of independent variables, four subtests (i.e., phonological deletion, phonological blending, phonological discrimination, and phonological substitution) were analyzed for phonological awareness. We analyzed number, letter, object, and color for RAN test, and alphabet knowledge and sound-letter correspondence knowledge for

Table 1
Descriptive Statistics for All Measures in the Study (n=155)

Variable	Range	Min	Max	M(SD)
Phonological Awareness				
Phonological Deletion	0-16	2	16	11.72(3.12)
Phonological Blending	0-16	0	16	10.15(3.78)
Phonological Discrimination	0-16	0	16	9.72(3.50)
Phonological Substitution	0-16	0	16	8.78(4.48)
Rapid Automatized Naming(RAN)				
Digits Naming *		.22	2.78	1.45(0.47)
Letters Naming *		.39	1.67	0.92(0.29)
Objects Naming *		.28	1.61	0.77(0.18)
Colors Naming *		.28	1.39	0.77(0.21)
Orthographic Knowledge				
Sound-letter Correspondence	0-30	5	30	24.75(6.26)
Alphabetic Knowledge	0-40	3	39	29.65(7.84)
Working Memory				
Verbal Working Memory	0-24	4	19	10.14(2.67)
Visuo-spatial Working Memory	0-20	4	16	8.94(2.73)
Reading Achievement				
Word Recognition	0-45	4	40	27.92(7.49)
Pseudo-word Recognition	0-45	3	45	26.46(7.48)
Reading Fluency	0-627	20	346	178.63(65.26)
Reading Comprehension	0-30	2	30	19.28(5.17)

Note. *: Unit is number of reading item (reading speed in 1 second)

Table 2
Zero-Order Correlations (n=155)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1																	
2	.82***	1																
3	.77***	.76***	1															
4	.77***	.85***	.79***	1														
5	.54***	.58***	.53***	.59***	1													
6	.51***	.51***	.45***	.50***	.62***	1												
7	.50***	.56***	.57***	.59***	.49***	.65***	1											
8	.53***	.56***	.62***	.59***	.63***	.59***	.65***	1										
9	.75***	.73***	.60***	.68***	.49***	.49***	.48***	.46***	1									
10	.70***	.70***	.62***	.67***	.48***	.49***	.46***	.46***	.83***	1								
11	.54***	.54***	.44***	.47***	.35***	.25**	.28***	.38***	.52***	.44***	1							
12	.32***	.32***	.42***	.30***	.30***	.19*	.31***	.39***	.25**	.24**	.38***	1						
13	.86***	.87***	.84***	.86***	.73***	.69***	.73***	.76***	.81***	.78***	.62***	.49***	1					
14	.72***	.64***	.55***	.62***	.52***	.48***	.45***	.46***	.84***	.75***	.49***	.27***	.78***	1				
15	.76***	.67***	.59***	.66***	.55***	.54***	.44***	.51***	.77***	.69***	.48***	.22**	.76***	.89***	1			
16	.70***	.70***	.60***	.64***	.61***	.58***	.56***	.54***	.69***	.58***	.44***	.25**	.69***	.72***	.78***	1		
17	.70***	.65***	.55***	.58***	.48***	.43***	.42***	.37***	.68***	.61***	.44***	.30***	.76***	.77***	.80***	.73***	1	
18	.79***	.73***	.64***	.69***	.59***	.56***	.51***	.52***	.79***	.70***	.51***	.28***	.89***	.96***	.95***	.90***	.89***	1

Note. 1 = Phonological Deletion, 2 = Phonological Blending, 3 = Phonological Discrimination, 4 = Phonological Substitution, 5 = Digits Naming, 6 = Letters Naming, 7 = Objects Naming, 8 = Color Naming, 9 = Sound-letter Correspondence, 10 = Alphabetic Knowledge, 11 = Verbal Memory, 12 = Visuo-spatial Memory, 13 = Total Score of Screening test, 14 = Word Cognition, 15 = Pseudo-word Cognition, 16 = Reading Fluency, 17 = Reading Comprehension, 18 = Total Score of Reading Test.
*$p<.05$, **$p<.01$, ***$p<.001$

Table 3

Summary of Multiple Regression Analyses for Reading Achievement (n= 155)

Dependent Variable	Predictor Variable	β	R^2	ΔR^2	F
Total of Reading	Step 1				
	Sound-letter Correspondence	.792	.628		258.035***
	Step 2				
	Sound-letter Correspondence	.454	.718	.090	193.303***
	Phonological Deletion	.452			
	Step 3				
	Sound-letter Correspondence	.420			
	Phonological Deletion	.381	.740	.022	143.061***
	Digits Naming	.178			
Word Recognition	Step 1				
	Sound-letter Correspondence	.787	.620		249.362***
	Step 2				
	Sound-letter Correspondence	.477	.696	.076	173.630***
	Phonological Deletion	.415			
	Step 3				
	Sound-letter Correspondence	.453			
	Phonological Deletion	.365	.706	.011	121.156*
	Digits Naming	.126			
Pseudo-word Recognition	Step 1				
	Sound-letter Correspondence	.773	.597		227.110***
	Step 2				
	Sound-letter Correspondence	.469	.670	.073	154.469***
	Phonological Deletion	.406			
	Step 3				
	Sound-letter Correspondence	.441			
	Phonological Deletion	.348	.685	.015	109.472**
	Digits Naming	.146			
Reading Fluency	Step 1				
	Phonological Deletion	.704	.496		150.664***
	Step 2				
	Phonological Deletion	.526	.573	.077	101.880***
	Digits Naming	.329			
	Step 3				
	Phonological Deletion	.314			
	Digits Naming	.292	.614	.041	80.145***
	Sound-letter Correspondence	.311			
	Step 4				
	Phonological Deletion	.282			
	Digits Naming	.246	.632	.017	64.277**
	Sound-letter Correspondence	.279			
	Objects Naming	.161			
Reading Comprehension	Step 1				
	Phonological Deletion	.697	.486		144.674***
	Step 2				
	Phonological Deletion	.422	.546	.060	91.290***
	Sound-letter Correspondence	.368			

*p<.05, **p<.01, ***p<.001

orthographic knowledge. Lastly, verbal and visuospatial working memories were analyzed for working memory. Dependent variables included word reading, pseudo-word reading, fluency, and comprehension.

Correlations

We calculated zero-order correlations for the entire dependent and independent variables (see Table 2). Total scores of a screening test and a reading ability test were calculated based on subscale scores.

A sum score of the screening test correlated highly with a sum score of the reading ability test (r=.89, p<.001). In addition, scores of sixteen subtests correlated significantly with each other. In terms of phonological awareness, the scores of phonological deletion, blending, and substitution correlated strongly with those of reading ability test, while phonological discrimination correlated moderately with all measures of reading ability.

The reading ability correlated moderately with RAN (r=.42~.61, p<.001); however, this relationship was relatively weaker than were those of reading ability and phonological awareness. Especially letter naming, a subtest of the RAN test, showed a small correlation with visuospatial working memory (r=.19, p<.05).

In terms of the relationship between orthographic knowledge and reading ability, the score of word reading correlated most strongly with the score of sound-letter correspondence (r=.84, p<.001). Lastly, visuospatial working memory had the weakest correlation with all measures in this study.

Regression Analyses

We conducted stepwise regression to investigate the ability of a screening test to predict the children's reading ability. This method is known to prevent multicollinearity and reduce error when including multiple independent variables.

Phonological deletion, digit naming, and sound-letter correspondence knowledge predicted the total score of a reading ability test, accounting for 74% of the total variance of a sum score of the reading ability test. Among these significant predictors, sound-letter correspondence knowledge was the most powerful variable, accounting for 62.8% of the variance in reading ability (see Table 3).

Of the subscales included in reading ability test, sound-letter correspondence, phonological deletion, and digit naming predicted word-reading ability. These variables accounted for 62%, 7.6%, and 1.1% of the variance in the word reading ability measures, respectively (see Table 3). In case of pseudo-word reading, the prediction ability of sound-letter correspondence was most powerful, accounting for 59.7% of the variance in the pseudo-word reading (see Table 3).

Phonological deletion, digit naming, sound-letter correspondence, and object naming related significantly to reading fluency. Phonological deletion predicted reading fluency most strongly, accounting for 63.2% of the variance in the reading fluency (see Table 3).

Phonological deletion and sound-letter correspondence predicted comprehension. Combined predictive power of these variables accounted for 54.6% of the total variance in the reading comprehension measure (see Table 3).

Study 2
The effectiveness of an early intervention for children at risk of reading underachievement

Methods

Participants

In study 2, children who participated in Study 1 were ranked in percentiles according to the screening test result. As suggested in Study 1, 37 children whose scores on a screening test ranked lower than the 20th percentile were considered high-risk, thus they were involved in the early intervention program (Kim et al., 2003; Compton, 2000; Shaywitz et al., 1995; Torgesen,

Wagner,, 1997). These children were randomly assigned to control group or treatment group. Treatment group consisted of 15 children and control group consisted of 22 children. Four children in the control group and one child in the treatment group dropped out of the study due to illness, transferring to another school, and moving to another city. Therefore, final analysis was obtained from 14 children.

The Early Intervention Program

The early intervention program developed for this study included phonics, phonological awareness, reading fluency, and comprehension. This program consisted of 40 sessions in four stages. Broadly, the first stage consisted of introduction, enhancing motivation, and learning about basic vowels and consonants. The second stage consisted of learning words based on alphabet knowledge that correspond to Korean notation. This stage is also linked to phonological awareness, orthography, listening skill training, and attention improvement strategy. The third stage required children to read a short sentence both quickly and accurately. In the final stage, children learned phonological processes pattern. The final goal of this program was to improve reading fluency and comprehension.

Procedures

The early intervention was conducted individually. A total of 40 sessions were conducted from May to October. The early intervention was conducted twice a week. Duration of the program was about 30-40 min, and 60 min in case of group session. One Ph.D. student and one M.A. student with specialty in reading disorder led the early intervention for children at-risk of reading underachievement. Written informed consent was obtained after providing subjects and their parents with a full description of the study.

To verify the effectiveness of the early intervention, a reading ability test was administered three times, at the beginning of the program (May), in the middle of the program (August), and at the end of the program (November). Study 2 used the same measures for assessing reading ability as study 1.

Data Analysis

In order to examine the effect of participation of early intervention program on differences in reading achievement, 3 reading test scores administered to treatment group and control group were compared by independent t-test. Also, repeated measure ANOVA was performed to examine the effect of program participation and passage of time (assessment performed in May, August, and November) on reading score. Furthermore, simple main effects of time and group were each analyzed.

Results

Following is the result of comparison of reading abilities before treatment. Before performing early intervention program to improve reading skills, 3 tests were each given to both treatment group and control groups; the average scores of each subtests was compared by t-test. As shown in Table 4, there was no significant difference in word reading, reading fluency, and reading comprehension between pretest administered to 2 groups in May. However, significant group difference was found in word reading test administered in August and November; reading fluency did not show any significant difference between groups. For reading comprehension subtest, group difference was reported in final November test but not in May or August. Meaningless word reading was given only in November due to extraneous problems, and there was significant group difference.

Results of examination of early intervention program effect are as follows: both treatment and control groups took the assessment of reading ability before (May), during (August), and after (November) the treatment. To examine whether or not the program has effect on enhancing reading skills, repeated measure ANOVA was

Table 4
Scores on Reading Ability Test for Children in the Intervention Group and the Control Group

	Pre-test Mean (*SD*)	Intermediate Test Mean (*SD*)	Post-test Mean (*SD*)
Word reading			
Intervention group	13.14 (6.59)	21.86 (5.05)*	28.43 (4.15)***
Control group	14.83 (6.62)	16.00 (6.84)	19.11 (7.89)
Reading fluency			
Intervention group	57.57 (42.61)	104.12(49.37)	148.32 (52.45)*
Control group	69.39 (49.32)	92.95 (55.57)	107.25 (57.83)
Reading comprehension			
Intervention group	6.29 (5.62)	14.64 (5.98)	20.00 (4.13)***
Control group	6.44 (5.09)	10.61 (6.05)	13.11 (5.93)
Pseudo word reading			
Intervention group			25.64 (3.59) ***
Control group			17.89 (7.71)

*p<.05, ***p<.001

Table 5
Summary of Repeated Measure Analysis for Reading Achievement

Repeated measure ANOVA	Variable	*Type Ⅲ SS*	*df*	*MS*	*F*
Ability of Reading	Between-Subjects				
	Group(experimental, comparison)	477.28	1	477.28	4.26*
	Error	3365.46	30	112.18	
	Within-Subjects				
	Time (May, Oct., Sep.)	1507.05	2	996.58	127.83***
	Time x Group	499.05	2	330.01	42.33
	Error	353.68	60	7.79	
Fluency of Reading	Between-Subjects				
	Group(experimental, comparison)	2889.65	1	2889.65	.61
	Error	2413.03	30	8043.43	
	Within-Subjects				
	Time (May, Oct., Sep.)	64040.44	2	38512.17	144.61***
	Time x Group	7691.57	2	4625.49	17.37***
	Error	13285.54	60	266.32	
Comprehension of Reading	Between-Subjects				
	Group(experimental, comparison)	304.02	1	304.02	3.71*
	Error	2455.81	30	81.86	
	Within-Subjects				
	Time (May, Oct., Sep.)	1664.16	2	832.08	164.89***
	Time x Group	197.91	2	98.95	19.61***
	Error	302.76	60	5.05	

*p <.05, **p<.01, ***p<.001

conducted with word reading, reading fluency, and reading comprehension as result variables and independent variables as 3 time points levels and 2 groups.

Repeated measure analysis showed that the reading ability score increased significantly over time (F=127.83, p<.001). Because interaction effect was also significant (F=42.33, p<.001), simple effect tests were conducted. According to simple effect tests, group differences were significant in August (F=7.19, p<.05) and November (F=16.01, p<.001).

Time x treatment interaction for reading fluency was significant. Early intervention group members showed larger improvements in reading fluency compared to control group members (F=17.37, p<.001). Analysis using simple effect tests showed a significant group difference on the reading fluency score assessed in November (F=4.30, p<.05).

In terms of reading comprehension, the main effect of time was significant within subjects. It indicated that both groups improved significantly in reading comprehension (F=164.89, p<.001). However, early intervention group members showed larger improvements in reading comprehension compared to control group members (F=6.32, p<.05). Simple effect tests were also conducted because time x treatment interaction effect was significant (F=19.61, p<.001). According to simple effect tests, group difference in reading comprehension was significant only in November (F=13.68, p<.001) (see Table 5).

Pseudo-word reading test was administered only once, in November, because we developed the test later. Significant difference was observed between the two groups (F=12.07, p<.001) (see Table 6).

Discussion

The goals of this study were to develop a screening test for the children most at risk of reading underachievement and to evaluate the effectiveness of the early intervention for children at risk of reading underachievement.

The Usefulness of the Screening Test

Study 1 investigated the predictive accuracy of a screening test composed of phonological awareness, orthographic knowledge, RAN, and working memory. First, the total score on the screening test correlated significantly with the total score on the reading ability. In addition, this score accounted for 74% of the total variance in measures of reading ability. Thus, the score on the screening test at the beginning of the school year could significantly predict the reading ability at the end of the school year. More specifically, sub-tests of the screening test, that is, sound-letter correspondence knowledge, phonological deletion, and digit naming, were significant predictors of reading ability.

Thus, phonological awareness, orthography, and RAN seem to reflect pre-reading skills that can predict reading development efficiently. The strong relationship between reading ability and orthographic knowledge and the relationship between reading ability, phonological awareness, and naming found in this study are consistent with the results of previous studies (Adams, 1990; Badian, 2001; Bell, McCallum, & Cox, 2003; Berninger et al., 2002; Denckla & Cutting,

Table 6
Result of One-way ANOVA for Psudo Word Reading Achievement

One-way ANOVA	Variable	*df*	*SS*	*MS*	*F*
Meaningless word	Between-Subjects	1	473.48	473.48	12.07***
	Within-Subjects	30	1176.99	30.23	.23
	Universe set	31	16143		

***p<.001

1999; Wolf & Bowers, 1999). Although working memory was not included in regression analysis, verbal working memory related to reading ability, which supports the results of previous studies (Catts, Fey, Zhang, & Tomblin, 2001; McCallum et al., 2006; Powell et al., 2007). On the other hand, visual working memory showed slight correlation with reading ability. This finding is consistent with Kim's (1998) study, which investigated the relationship between visual working memory and reading ability.

In terms of sub-tests representing four variables of a screening test, the effectiveness of the sub-tests was consistent with findings from previous studies. Phonological deletion task for phonological awareness (Coyne, Kameenui, & Simmons, 2001), digit naming for RAN (Compton, 2000; Frederickson, 2006), and sound-letter correspondence knowledge for orthography (Kim, 1995; Oh, 2006) were identified as significant predictors.

According to these results, it seems that the screening test composed of multiple constructs could predict the reading ability most effectively. Thus, for early identification of children at risk of reading underachievement, it would be very useful to develop the comprehensive test that would include orthography, phonological awareness, and RAN. Furthermore, sound-letter correspondence knowledge, phonological deletion, and digit naming were identified as the most powerful predictors in this study, accounting for a large portion of the reading ability. Therefore, the combination of these subtests could make a screening test more convenient and efficient.

The results that showed sound-letter correspondence knowledge was a powerful predictive variable of word recognition ability imply that it would be quite important to incorporate contents related to orthography into an intervention program. The level of understanding the correspondence pattern between sound and letter could be critical for reading development at an early stage. This finding also supports the validity of the phonics instruction emphasizing sound-letter correspondence knowledge.

In terms of verbal fluency, both sub tests of RAN, digit naming and object naming, predicted verbal fluency. A common factor of verbal fluency and RAN is a 'processing speed' because both tasks require rapid and accurate reading ability. Verbal fluency related more to phonological awareness than did RAN tasks. However, if we consider first grade as a critical period to acquire word recognition rather than fluency, naming speed will be more significant factor over time. Thus, longitudinal study on the relationship between verbal fluency and RAN is needed.

Only two variables, phonological deletion and sound-letter correspondence, predicted reading comprehension. These factors accounted for 55% of the variance, relatively low value compared to the other reading abilities. Thus, reading comprehension could relate more to vocabulary, grammar knowledge, and pre-learning experiences than the factors included in the screening test. Moreover, the task used in this study was relatively simple and easy; therefore, the average score was slightly high. This simplicity of the task could affect the study results. Thus, investigating reading comprehension using other tasks or diverse sentence formations will be useful in the future study.

The Effectiveness of an Early Intervention

In study 2, we developed the intervention program to improve reading ability for children at risk of reading underachievement and examined the effectiveness of that program. At first, children whose scores on the screening test were lower than the 20th percentile were randomly assigned to intervention group or control group. The semi-weekly program lasted six months. Overall, eight sessions were conducted. Generally, word recognition, fluency, and reading comprehension ability of the children in the intervention group improved significantly. Furthermore, reading ability of the children in the intervention group improved considerable compare to the children in the control group. Although, the progression of

pseudo-word reading ability over time could not be investigated in this study, our findings showed significant group difference on pseudo-word reading ability in November. This result has some implication because pseudo-word reading is known to be more difficult than word reading, according to previous researches. Thus, word recognition ability could improve dramatically by phonics instruction. Concerning reading development stage, the ability to read words accurately is an important achievement task. If children have difficulty in word recognition tasks, this difficulty could affect their verbal fluency and ability to understand the meanings of sentence consecutively. These results were consistent with the findings from previous studies, which suggested that most reading problems are due to poor word decoding ability; therefore, phonics instruction or word decoding instruction could help improve this deficiency (Siegel, Share, & Geva, 1995; Hammill, 2004; Holland et al., 2004).

The two groups did not differ in verbal fluency, although the score of the intervention group improved more than that of the control group. This result is in agreement with the findings of previous studies (Ehri et al., 2001). It is likely that a short time intervention may not improve verbal fluency. In other words, although intervention effectively improves verbal fluency, this effect does not seem to be immediate, unlike the effect of word decoding ability. Thus, continuous intervention that would include multiple constructs, according to the dimension of reading ability, would be needed. The reading comprehension of intervention group also improved more compared to the control group; although, the degree of improvement was relatively small compared to word decoding ability. However, the difference between two groups in reading comprehension further accentuated over time. Therefore, if the long-term intervention were possible, reading comprehension could improve as much as word decoding. The results that word recognition ability could make verbal fluency and reading comprehension easier support the necessity to develop an intervention focusing on reading recognition, especially for the elementary first grade students. Children could become skilful readers by accumulating sight words, which are automatically read in their mental lexicon. This is achieved by repetitive reading process of even unfamiliar words or pseudo-words.

Individual difference in reading ability does not resolve naturally overtime, instead, the discrepancy seems to increase (O'Connor, 2000). Although the reading ability of children in the control group improved to some degree, the degree of improvement was small compared to that of the intervention group. This result also emphasizes the importance of an early stage intervention.

This study introduced flexible content or method of intervention adjusted to individual differences. In other words, the intervention conducted in this study utilized multivariate approach focusing on different reading components according to individual differences. Children at risk of reading underachievement have different developmental and psychological needs and manifest various problems. Thus, multiple approaches, including diverse reading related components would be more helpful, although phonics instruction is effective in improving reading.

Lastly, it is important to acknowledge the limitations of the present study. First, the phonological awareness, alphabet knowledge, and RAN measures were developed for this study. Thus, the standardized reading ability assessment that could be utilized in Korea is still needed. Second, we have so far been unable to conduct follow-up assessments on all children in the study. In the future study, trend analysis including follow up data will be useful.

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