

The Effect of Phonological Knowledge-Based Writing Intervention on the Spelling Knowledge and Phonological Awareness of Children with Borderline Intelligence

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Purpose: Children with borderline intelligence have difficulty with phonological awareness and decoding. This study aims to examine the spelling abilities of borderline and typical children and determine their difference in spelling abilities after an intervention with a phonological knowledge-based spelling program.

Methods: The study subjects were four borderline-intelligent children and four normal-intelligent children in the third and fourth grades of elementary school whose teachers or parents reported having no sensory impairment, had an error variance of -1 SD or less on a phonological knowledge-based listening and writing test, and had normal reading achievement and reading cognitive processing skills according to RA-RCP.

Results: This study showed that improving spelling knowledge through phonological knowledge-based writing intervention is possible. In particular, the phonological fluctuation score and spelling error rate of borderline intellectual children decreased significantly after the intervention, proving the effectiveness of the intervention. The phonological knowledge-based writing intervention had a positive effect on both borderline and typical children, but the gap between borderline and typical children was not completely closed. Intelligence and vocabulary significantly impacted the development of phonological knowledge, while age had no significant correlation.

Conclusions: In terms of phonological manipulation skills, typically developing children performed well on phonological manipulation tasks. With delayed responses, children with borderline intelligence showed limited performance on these tasks. When it came to understanding phonological rules, typically developing children consistently processed rule-based spelling and pronunciation, while borderline children were limited to simple rule application and had difficulty handling complex variation.

Keywords: Writing intervention spelling knowledge, Phonological knowledge base, School-age children, Literacy, Literacy intervention



Received: December 9, 2024

Revision: December 31, 2024

Accepted: December 31, 2024

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INTRODUCTION

Children with borderline intelligence are not eligible for special education, but they show difficulties in literacy due to their limited intellectual abilities in general education [1]. In particular, phonological awareness is highly correlated with spelling and is

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mediated through repetitive training as a precursor to spelling [2]. Phonological awareness is recognizing phonemes, the minor units of sound, and encoding and manipulating them as a single representation [3]. Children can initially use their phonological knowledge to write letters based on grapheme-phoneme correspondences, and later, they can write words or syllables that contain phonological rules. The knowledge of graphemes is the knowledge of the form and structure of letters, the order of strokes, and the combination of name words. In contrast, the knowledge of phonemes is the knowledge of the units of speech sounds and the identification of sounds. Hangul is a language with regular grapheme-phoneme correspondences in the written script. However, this is true for monosyllabic words, and phonological fluctuations occur when syllables are combined to form the next syllable [4]. Of the sub-domains of writing, children with borderline intelligence have the most difficulty with spelling and struggle with phonological awareness and decoding, which involves recognizing letters and sounds and distinguishing between word forms [5]. A phonological rule is a rule that governs how a phoneme changes depending on its environment. In Korean, phonological rules include syllable end sound rules, lenition, nasalization, rhoticization, palatalization, contraction, and elision. In Korea, phonological processing knowledge is essential due to the large number and variety of phonological variations and the fact that sounds on two boundaries change when syllables meet. Lack of phonological knowledge is the most important characteristic of spelling errors in writing [4].

Children with borderline intelligence tend to have difficulty with higher-order language activities such as spelling, which leads to problems with academic skills such as writing. They also have slower cognitive skills, vocabulary, and metaphorical reasoning development and lack the metacognitive skills to improve their phonological knowledge. This lack of phonological knowledge is a major contributor to spelling errors, leading to poor-quality writing. Therefore, there is a need for a systematic and empirical approach to improving the writing and spelling skills of children with borderline intelligence.

In this study, we aimed to investigate the effectiveness of a phonological knowledge-based writing intervention to improve spelling knowledge among the writing skills required for children with borderline intelligence. The research questions for this study are as follows: First, the effect of phonological knowledge-based writing intervention on the spelling knowledge of borderline and normal children; second, the effect of phonological knowledge-based writing intervention on

the phonological changeability of borderline and normal children; and third, the factors affecting the writing ability of borderline and normal children.

METHODS

Research subjects

The subjects of the study were four borderline intelligent children and four normal intelligent children in the third and fourth grades of elementary school who teachers or parents reported as having no sensory impairment, with an error deviation of -1 SD or less on the phonological knowledge-based listening and writing test, and normal reading achievement and reading cognitive processing ability according to RA-RCP. Children with borderline intelligence were selected as those who scored between 70 and 85 on the Korean version of the Wechsler Intelligence Scale, 5th edition [6], with a receptive or expressive vocabulary score of -1 SD or less on the receptive and expressive vocabulary test, and a metaphor/inference comprehension test [7], with results in the high-need or at-risk group.

Children with normal intelligence were selected as those with no problems in receptive and expressive language skills and who showed difficulties in writing. Table 1 shows the general characteristics of the study subjects.

Phonological knowledge-based writing intervention program

To develop a phonological knowledge-based writing intervention program, 240 vocabulary words were first selected by analyzing elementary school textbooks, and 80 final words were chosen for intervention by considering the types of phonological changes among the selected vocabulary words. The

Table 1. General characteristics of the study participants

Group	Participant	Chronological age	K-WISC-V
Normal intelligence	A	9;9	111
	B	9;9	99
	C	9;8	97
	D	8;7	95
Borderline intelligence	E	9;6	82
	F	10;2	79
	G	9;4	76
	H	10;2	74

types of phonological changes consisted of plain closure, consonantal simplification, softening, nasalization, lenition, palatalization, addition, and deletion. The intervention program consisted of 16 sessions explaining the concept of phonological changes, finding the target word, and creating sentences containing the target word.

Research procedure

The study was divided into pre-assessment, intervention, and post-assessment for each group to investigate the effectiveness of the phonological knowledge-based spelling program.

The phonological knowledge-based listening and writing test was conducted in the pre-assessment. The phonological knowledge-based spelling intervention was conducted twice a week for 40 minutes each time for 16 sessions, and an interim test was conducted once every four sessions. The intervention was conducted face-to-face with the child in a quiet, one-on-one setting. The posttest was administered at the exact location as the pretest, using the same instruments and methods.

Results processing and analysis

Statistical analyses were conducted using SPSS 30.0 for Windows using a mixed-design repeated measures analysis of variance (mixed-design ANOVA) with treatment as a between-group factor and pretest-posttest as a within-group factor. A t-test was performed to check for differences between pretest and posttest.

RESULTS

This intervention aimed to investigate the spelling ability of borderline and normal children and to find out their difference in spelling ability after the intervention of a phonological knowledge-based spelling program. For this purpose, a phonological knowledge-based listening and writing test examined the spelling ability of borderline and normal intelligence children.

Table 2. Analyzing pre-post differences between borderline and typically developing children

Factors	F
Borderline Intelligence-Normal (2)	3.45
Prepost (2)	5.67*
Borderline Intelligence-Normal (2)×Prepost (2)	4.23*

* $p < 0.05$.

Effects of phonological knowledge-based writing intervention on the spelling knowledge of children with borderline intelligence and children with normal intelligence

To investigate the effect of phonological knowledge-based writing intervention on borderline and normal-intelligence children, the pretest was repeated in the posttest. Repeated measures analysis of variance and a t-test were conducted to examine the differences in spelling writing ability between the pretest and posttest. The results of repeated measures analysis of variance and t-test were conducted to examine the effect of the phonological knowledge-based writing intervention on the pretest and posttest by group, as shown in Table 2.

As shown in Table 2, the main effect between pretest and posttest by group was statistically significant ($F = 5.67, p < 0.05$). However, the between-group main effect was not statistically significant ($F = 3.45, p > 0.05$). There was also an interaction effect between pretest and posttest ($F = 4.23, p > 0.05$). As the interaction effect was significant, we conducted a simple primary effect analysis by factor, and the results are shown in Table 3.

As shown in Table 3, the average total score for children with borderline intelligence increased by 6.5 from the pretest to the posttest, while for children with typical intelligence, it increased by 9.75. The pretest-posttest results for spelling skills showed a significant difference for both borderline and typical children ($t = 4.111, 6.166, p < 0.05$). When comparing the differences between the groups, there was no significant difference between pre and post ($t = 1.255, 1.486, p > 0.05$). This result suggests that the phonological knowledge-based writing intervention has a positive effect on writing skills. Still, there is no difference in effectiveness between the two groups. The pre-post changes are shown in Figure 1.

Effects of phonological knowledge-based writing intervention on phonological changeability of borderline and normal children

An interim evaluation was conducted to examine the effects and changes of the phonological knowledge-based writing intervention on children with borderline intelligence and nor-

Table 3. A t-test of spelling ability in borderline and typical children with intellectual disability

	Pre	Post	t
Normal (N=4)	60.75 (18.04)	70.50 (14.73)	4.111*
Borderline intelligence (N=4)	46.25 (14.43)	52.75 (18.80)	6.166*
t	1.255	1.486	

* $p < 0.05$.

mal children. The interim evaluation was conducted once every four sessions of the intervention. The results of the interim evaluation are shown in Table 4.

Both typical and borderline children made the most errors in allophonization. Throughout the intervention, the typical children showed a decrease in error rates, particularly in the lenition and nasalization items, which had relatively high error rates at the pretest, and a decrease in addition and substitution errors.

The borderline-intelligent children showed less overall error reduction than the typical children but significantly decreased plosive closure phonation errors. Figure 2 shows the changes in phonological variation errors by group.

In the phonological variation subscale, the typical child had the highest score of 9 for allophone errors. The frequency of errors was as follows: allophone (9.00), palatalization (7.25), lenition (6.50), softening (6.25), consonant simplification (6.00), nasalization (6.00), plosive closure (4.50), hardness

(3.50), and addition and elision (0). The change in phonological variation errors for typical children is shown in Figure 3.

Children with borderline intellectual disability had the highest score of 10 on the phonological variability subscale for allophone errors, with the following error frequencies: allophone (10.00), lenition (9.25), nasalization (9.00), consonant simplification (8.25), softening (8.00), plosive closure (7.75), hardness (6.50), palatalization (5.75), and addition and deletion (5.00). Within the phonological fluctuations subscale, the most significant reductions in error rates were for addition and elision errors. Children with borderline intelligence improved their scores throughout the intervention but showed less change in errors than children with typical intelligence. Among the phonological variation rules, there were improvements in allophones and rimes, but high error rates persisted on some items. Figure 4 shows the rate of change by error type for children with borderline intelligence.

The gap in spelling knowledge between the two groups re-

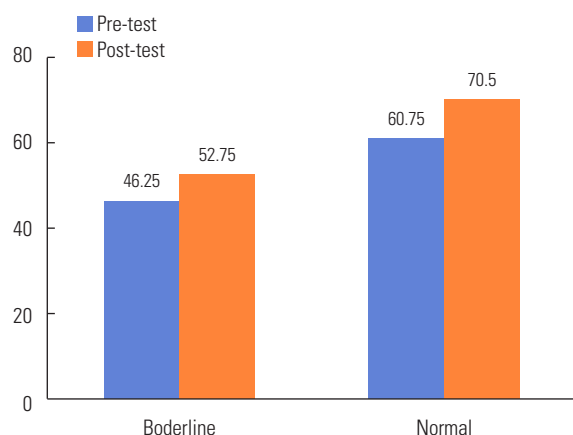


Figure 1. Phonological knowledge-based listening and writing tests.

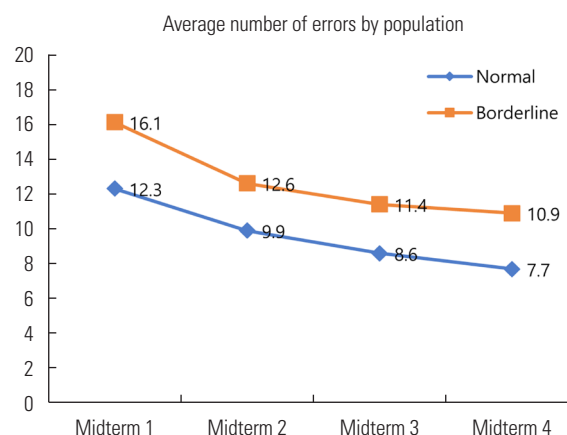


Figure 2. Errors by group in a phonological knowledge-based listening and writing intervention.

Table 4. Midterm assessment results by cohort

Error type	Normal intelligence				Borderline intelligence			
	Midterm 1	Midterm 2	Midterm 3	Midterm 4	Midterm 1	Midterm 2	Midterm 3	Midterm 4
Unreleased stopping	4.5	3.75	3	2.5	7.75	5.25	4	3.75
Consonant cluster simplification	6	4.25	4	3.5	8.25	5.75	5.25	4.5
Lenition	6.25	5	4.25	3.5	8	6.75	6	5.75
Nasalization	6	4.25	4	3.5	9	7.25	6.25	6.25
Lateralization	6.5	5.5	4.75	4.25	9.25	8.25	8	7.75
Tensification	3.5	2.25	2	2	6.5	5.25	4.75	4.25
Aspiration	9	8	7	6.75	10	8.75	8.25	8.25
Palatalization	7.25	6.5	5.25	4.75	5.75	3.25	3.25	3.25
Addition/Deletion	0	0	0	0	5	5	4.5	3.5

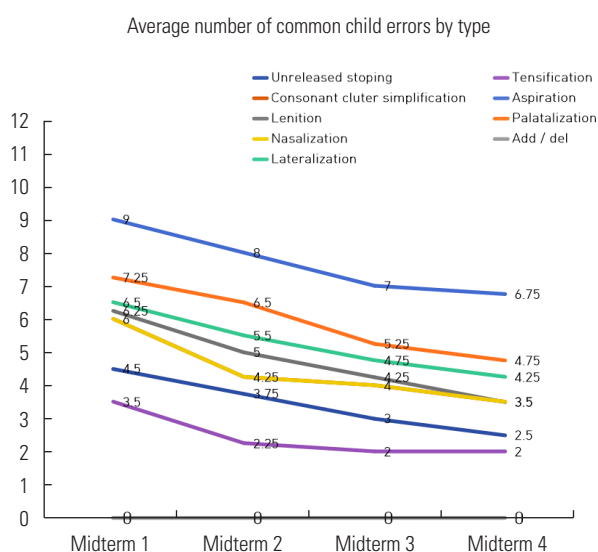


Figure 3. Types of phonological fluctuation errors in typical children with phonological knowledge-based reading intervention.

mained after the phonological knowledge-based writing intervention. Although the phonological knowledge-based intervention was effective for both groups, the gap did not close after the intervention. Given that this gap remained after the intervention, the pattern of score improvement was different, and more intensive and customized intervention programs are needed for children with borderline intelligence.

The intervention program was effective for both groups, but borderline children had more difficulty applying sound rules and spelling knowledge. This suggests that a more targeted and intensive strategy is needed, given the speed and level of learning of borderline children. Children with borderline intelligence have greater deficits in spelling knowledge than children with typical intelligence, likely due to difficulties in understanding and applying phonological rules. When looking at the differences in spelling knowledge between borderline and typically developing children, borderline children have greater difficulty understanding and applying phonological rules and make higher error rates in spelling than typically developing children.

Factors affecting the writing ability of borderline and normal children

Pearson correlation analysis was conducted to examine whether a significant correlation exists between intelligence, years of life, and vocabulary scores for phonological knowledge in the borderline and normal children groups. The results are shown in Table 5.

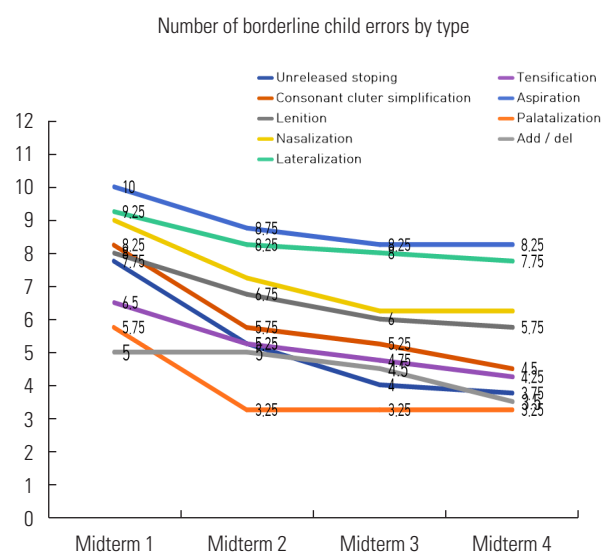


Figure 4. Types of phonological fluctuation errors in borderline children with phonological knowledge-based listening and writing intervention.

Table 5. Correlations between phonological knowledge and intelligence, years of life, and vocabulary scores within the borderline and average intelligence cohorts of children

Variable 1	Variable 2	Correlation coefficient
IQ	Age	-0.15
IQ	REVT-Receptive	-0.72
IQ	REVT-Expressive	-0.72
IQ	Pretest	-0.72
IQ	Posttest	-0.72
Age	REVT-Receptive	-0.15
Age	REVT-Expressive	-0.15
Age	Pretest	-0.15
Age	Posttest	-0.15
REVT-Receptive	REVT-Expressive	-0.68
REVT-Receptive	Pretest	-0.68
REVT-Receptive	Posttest	-0.66
REVT-Expressive	Pretest	-0.69
REVT-Expressive	Posttest	-0.72
Pretest	Posttest	0.78

Intelligence and phonological variation scores showed a negative correlation ($r = -0.72$) between IQ and phonological variation scores. This indicates that the lower the level of language development, the lower the understanding of phonological rules and spelling knowledge. A significant negative correlation ($r = -0.68$) was also found between receptive-expressive vocabulary (REVT) skills and phonological variation

scores. There was no significant correlation between years of life and phonological fluctuation scores ($r = -0.15$). In conclusion, we can see that intelligence and vocabulary are the main variables of phonological knowledge and that age at birth is not significantly related to spelling knowledge development. There were significant correlations between spelling knowledge and intelligence and vocabulary, suggesting that intelligence and vocabulary are key factors in the development of phonological knowledge and writing intervention effectiveness.

DISCUSSION

This study aimed to investigate the effects of a phonological knowledge-based writing intervention on the spelling knowledge of children with borderline intelligence. To this end, pretest and posttest changes were analyzed to compare the spelling knowledge of children with borderline intelligence and normal children to determine the difference in spelling knowledge between the two groups. The pretest and posttest scores showed statistically significant differences, suggesting that the intervention played an important role in reducing phonological variation errors. The between-group score differences were also crucial for most errors, implying that certain phonological error types may influence the intervention effect differently. These results suggest that phonological knowledge affects spelling.

Children with borderline intelligence scored an average of 46.25 (14.43) on the phonological knowledge-based listening and writing test. In terms of sub-phonological error types, the highest frequency of errors was found to be articulation errors (50.00%), followed by articulation (50.00%), nasalization (49.95%), plosives (40.00%), allophones (38.45%), consonant simplification (37.47%), plosives (29.97%), lenition (29.52%), addition and elision (25.00%), and palatalization (16.65%). The average score for normal children was 60.75 (18.04). In terms of sub-phonological error types, the highest frequency of errors was found in the form of allophone errors (55.00%), followed by allophone errors (55.00%), lenition (50.00%), consonant simplification (42.87%), palatalization (41.62%), softening (29.82%), nasalization (27.75%), plosive closure (17.85%), hardness (17.05%), and addition and elision (0%). The high prevalence of lenition errors in both borderline and normal children compared to other phonological errors is similar to previous studies showing that lenition errors are common even in older grades [8].

In the midterm evaluation of the phonological knowledge-based writing intervention, both typical and borderline children showed relatively higher frequencies of allophonic errors in the phonological fluctuation subscale, and errors in the form of transposition of final and initial consonants and phonetic errors were frequently observed. These results are consistent with a previous study [9] that examined the effects of a morphological awareness-based writing intervention program on the spelling of school-age dyslexic children.

Children with normal intelligence made fewer additions and deletions than children with borderline intelligence and were better able to handle the complexity of phonological shifts. Children with borderline intelligence were less likely to understand the rules of phonological variation and made more complex errors. The largest reductions in error rates in the phonological variation subscale were for addition and elision errors. Children with borderline intelligence improved their scores throughout the intervention but had a lower rate of error change than children with typical intelligence. At the final test, the gap between their scores and those of typically developing children remained. Both groups showed decreased error rates on the total score and the phonological variation subscale. Among the phonological variation rules, plosives showed the most significant error reduction, while plosives also showed high error rates. The results were similar to those of a previous study, which showed that the regularity of allophones is easy to understand but challenging to write [10].

This study showed that it is possible to improve spelling knowledge through phonological knowledge-based writing intervention. In particular, the phonological fluctuation scores and spelling error rates of borderline intellectual children decreased significantly after the intervention, proving the effectiveness of the intervention. Although the phonological knowledge-based writing intervention had a positive effect on both borderline and typical children, the gap between borderline and typical children was not completely closed. These results suggest the need for a systematic intervention program that supports the understanding and application of phonological rules. The results of this study demonstrate that phonological knowledge-based writing interventions can positively impact spelling knowledge in children with borderline intelligence and suggest the need to explore the underlying mechanisms by which these interventions work effectively.

To compare the phonological awareness of borderline and typical children, we analyzed different errors related to pho-

nological fluctuations. Phonological awareness refers to the ability to understand the sound system of a word and combine it with spelling and pronunciation. Here are the key findings: Intelligence and vocabulary significantly impacted the development of phonological knowledge, while age was not significantly correlated. This is consistent with findings from a study of the characteristics of writing development in elementary school students that showed that writing development does not necessarily improve with natural maturation or grade level [11]. This suggests that phonological knowledge development is more influenced by linguistic and cognitive factors, such as intelligence and vocabulary, than by natural maturation with age or grade level. Typical children demonstrated high levels of phonological discrimination and phonological manipulation skills; they could apply spelling rules in listening and writing, process complex phonological variation, and were particularly good at understanding and applying phonological rules for pronunciation and spelling. Children with borderline intelligence performed relatively poorly on phonological variation discrimination and phonological manipulation. A deficit in phonological awareness was observed, which affected the spelling-to-pronunciation process. Previous studies have shown that children with dysgraphia have significantly lower phonological awareness skills than typical children [12]. Therefore, a lack of phonological awareness skills in borderline children may lead to difficulties in academic performance, such as dictation. These findings emphasize that phonological awareness is an essential foundation for developing literacy skills such as decoding and spelling from the earliest stages of learning. This suggests that systematic and sustained intervention programs to strengthen phonological awareness skills are needed to support children with borderline intelligence learning.

In terms of phonological manipulation skills, typically intelligent children performed well on phonological manipulation tasks. With delayed responses, children with borderline intelligence showed limited performance on these tasks. In terms of phonological rule comprehension, typically developing children consistently processed rule-based spelling and pronunciation, while borderline children were limited to simple rule application and had difficulty processing complex variations.

The limitations of this study include the small sample size, which limits the generalizability of the results. Future research should be conducted with a larger sample size. Second, the study was limited to third and fourth graders, restricting the

applicability of the results to children in other grades. Future studies should broaden the grade range to include children from lower to upper grades to analyze grade-specific characteristics and developmental differences further. This would allow for a broader understanding of phonological awareness and writing development characteristics across grades.

This approach can provide an important basis for developing intervention strategies tailored to children's individual characteristics. The impact of factors other than phonological knowledge, such as visual learning styles and motivation, on spelling knowledge should also be analyzed. In addition, teachers and parents should be educated about the importance of phonological knowledge-based interventions so that they can be used effectively in real-world learning environments.

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