

Original Article

The Relationship between Vocabulary and Phonological Processing according to the Speech Sound Acquisition of 3-Year-Old Children

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Purpose This study examined the relationship between vocabulary and phonological processing skills across levels of speech sound acquisition and investigated whether speech sound acquisition influences these skills.

Methods Thirty-six typically developing 3-year-old children were divided into three groups (n = 12 each) based on their level of speech sound acquisition: Group A (complete acquisition), Group B (mispronunciations of fricatives only), and Group C (mispronunciations of fricatives and other sounds). Vocabulary skills were assessed using receptive and expressive vocabulary tests; phonological processing skills were evaluated with nonword and sentence repetition tasks. Group differences were analyzed using one-way analysis of variance (ANOVA) and Pearson's correlation coefficient, and variable influence was evaluated using logistic regression.

Results Both vocabulary and phonological processing differed significantly across groups, with Groups A and B outperforming Group C in all tasks. Receptive and expressive vocabulary scores, and nonword and sentence repetition scores, were significantly correlated. Higher scores in both domains increased the likelihood of belonging to Groups A or B rather than Group C.

Conclusions Vocabulary and phonological processing are strongly associated in typically developing 3-year-olds and early phonological development influences these skills. These results have implications for early language assessments and intervention strategies.

Keywords speech sound acquisition, vocabulary, phonological processing skills, early childhood, language development

INTRODUCTION

In the early postnatal period, children rapidly acquire a phonological system that combines speech sounds and meanings to enable communication [1]. The phonological system includes the acoustic properties of speech sounds and a list of phonemes from which meanings are derived. Phonology refers to the collection of individual sounds that form words, expressed through articulation, which is the phonetic embodiment of the internalized phonological system. To produce accurate speech sounds,

young children need to know the phonological rules of their native language and the motor skills necessary for speech. Effective communication requires clear articulation such that listeners can understand, which in turn depends on accurate phonological and articulatory production supported by precise control of the speech mechanisms.

Speech production problems are strongly linked to phonological deficits [2,3], characterized by difficulty perceiving phonemic differences that alter word meaning. Such deficits lead to frequent speech sound errors, re-

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duced intelligibility, and communication breakdown. They are also associated with early literacy and reading difficulties [4,5]. Understanding these issues in the early stages of development is essential to examining how the degree of speech sound acquisition influences the articulation of the phonological system.

Vocabulary is closely linked to phonology in early childhood, developing alongside word learning [6,7]. It builds on phonological skills [8], the ability to perceive and recognize speech units and produce phonemes, syllables, and words. Children expand vocabulary by controlling articulatory mechanisms for familiar and frequently used words. The accuracy of phonetic and phonemic matching is strongly influenced by their ability to produce speech sounds [9,10], as phonological knowledge encompasses individual phonemes, their arrangements, and the features that form vocabulary. New vocabulary is integrated with existing vocabulary through fast mapping and encoding within an acquired phonological system. As children construct their phonological systems, they apply acquired phonological information to motor planning, execution, and monitoring of speech production [11], enabling rapid vocabulary growth, from single words to combinations. Sosa and Stoel-Gammon reported that vocabulary and phonological development are closely related, with phonological characteristics influencing vocabulary size and word production [12,13]. If phonology is the individual sound unit of a word, vocabulary is the integrated sequences of those sounds [14, 15]. Storkel found that when phonology and vocabulary are learned simultaneously, phonological acquisition affects vocabulary acquisition [16]. Therefore, phonology is a predictor of vocabulary size [17,18], as producing words requires integrating phonological and semantic processes [19]. Vocabulary is foundational for speech and language development, critical in early childhood, and an indicator of a child's ability to perceive speech, form concepts, and produce language [20]. It is therefore essential in language assessment and interventions across language disorders.

Phonological processing refers to the ability to process complex linguistic information across utterances, from vowels and monosyllables to words and sentences. It involves understanding and producing word meanings, constructing sentences in spoken and written language, and monitoring and manipulating words in sentences. Phonological processing refers to the ability to discriminate and manipulate sounds, store new sequences of sounds, and retrieve phonological information, and it encompasses phonological awareness, phonological memory, and naming [21]. Maziero described it as access to phonology, vocabulary, and phonological working memory [22]. Phonological processing is closely tied to speech and cognitive skills, functioning as a meta-linguistic skill that integrates linguistic and cognitive information for language and literacy development [23]. It supports vocabulary acquisition, sentence comprehension, and reading fluency, all of which influence communication and early reading achievement [24,25]. Children with phonological processing deficits have difficulties with phonological awareness, grapheme-phoneme learning, and vocabulary acquisition due to reduced phonemic sensitivity [26]. They also have difficulty with syntactic awareness, which affects comprehension and communication [27]. Therefore, fostering phonological processing is essential for children to process language semantically, phonologically, and syntactically in communication.

Although phonological processing and the development of a phonological system are closely related to a child's speech production and speaking ability, speech-language pathology has given limited attention to articulation interventions focused on pronunciation. Existing research has largely examined children with and without speech-sound disorders, language-development disorders, or based on indicators of dyslexia and reading skills. While phonological processing skills and vocabulary development are closely linked in early childhood, the impact of speech-sound acquisition levels on these abilities in typically developing young children remains underexplored.

This study investigates the relationship between vocabulary and phonological processing skills in typically developing 3-year-old children.

Studies on Korean phonemic development indicate that age three marks the emergence of all speech sounds, with approximately 75% of children acquiring plosives and fricatives [28, 29]. It is also a critical period for phonological processing, as children transition from short, simple sentences to longer, more complex sentences. In this study, we examined expressive and receptive vocabulary and phonological processing in nonword and sentence tasks in children with and without full speech-sound acquisition. The nonword task was administered to 3-year-old children because vocabulary size is closely associated with the ability to produce nonwords at this age [30]. Phonological processing of varying complexity lengths was examined through repetition tasks as a meta-language for monitoring and syntactically recognizing word meanings and order within sentences to identify performance differences across speech-sound acquisition.

Understanding the phonological systems and processing abilities of 3-year-olds can help clarify the cognitive skills underlying language proficiency and vocabulary growth, and can guide clinical application for children with early developmental speech-production difficulties. This study aimed to examine whether vocabulary and phonological processing skills in typically developing 3-year-old children vary by speech-sound acquisition level by exploring the relationship between these abilities and assessing the extent to which speech-sound acquisition influences them. Insights from these findings may enhance early language development and inform speech and language assessment and intervention strategies for young children. This study addresses the following research questions:

1. Do vocabulary and phonological processing skills in typically developing three-year-old children differ significantly by speech-sound acquisition level?
2. What is the association between vocabulary and phonological processing skills in typically developing 3-year-old children across different speech-sound acquisition levels?
3. Does speech-sound acquisition level influence vocabulary and phonological processing skills in typically developing 3-year-old children?

METHODS

Participants

The study included 36 typically developing 3-year-old children (M:F=18:18) residing in Gyeonggi, South Korea. Each of the three groups comprised six boys and six girls to control for sex-related variation in speech-sound acquisition. All children were enrolled in two general daycare centers in the same area, reported by their primary caregivers and teachers as having no developmental delays, speech or language disorders, or other temperamental or developmental disorders. In the APAC' Word Test, Group A had a mean raw score of 0; Group B averaged 6.25, indicating errors limited to fricatives; and Group C averaged 14.25, indicating errors in fricatives and other sounds (Table 1).

Assessment tools and data collection

The assessment tools comprised the Receptive & Expressive Vocabulary Test (REVT) [31], Assessment of Phonology and Articulation for Children (APAC) [32] and nonword and sentence repetition tasks. All assessments were conducted at two institutions, with sufficient

Table 1. Information of Participants

	Group A (n=12)	Group B (n=12)	Group C (n=12)
Age (month)	43.50	41.67	40.00
APAC (word)	0.00	6.25	14.25

Values are presented as means.

APAC=Assessment of Phonology & Articulation for Children.

rapport established beforehand to account for participants' age.

The REVT and APAC word tests were administered to test vocabulary and speech-sound development, while the nonword and sentence-repetition tasks were administered to examine phonological processing skills. The nonword task consisted of one to five syllables, and the sentence task consisted of four sentences, including single and double sentences from the APAC speech test. For the nonword and sentence tasks, children practiced three samples to recognize the test method. Incorrect or absent responses during the tasks were retold only once, with no additional opportunities allowed. For the sentence task, picture cues were provided to prompt sentence production. The assessment process was recorded using an iPhone 14 (iOS 17.6.1). All recorded speech samples were transcribed, and responses were scored as 1 for correct responses to the target syllables and sentences and 0 for incorrect responses or no responses.

Data analysis

A one-way ANOVA was conducted to examine group differences between groups A, B, and C in speech sound acquisition. Pearson's correlation coefficients (Pearson's r) were calculated to assess correlations between expressive and receptive vocabulary and phonological processing (nonword and sentence repetition). Logistic regression was used to analyze whether speech sound acquisition affected vocabulary and phonological processing abilities. All statistical analyses were performed using SPSS 26.0.

Reliability

In addition to the researcher, two first-level speech-language pathologists with master's degrees in speech-language pathology and with more than five years of clinical experience participated in the reliability assessment.

A reliability assessment was performed by analyzing 20% of the data of the 36 participants. The agreement rates were 99.8% for REVT and APAC, and 99.6% and 98.3% for the nonword and sentence-repetition tasks, respectively.

RESULTS

Differences in vocabulary and phonological processing skills by speech-sound acquisition level

To investigate differences in vocabulary and phonological processing skills of 3-year-old children according to speech-sound acquisition level, vocabulary was divided into expressive and receptive components, and phonological processing into nonword repetition and sentence repetition tasks. Descriptive statistics are presented in Table 2.

First, for REVT Expressive Vocabulary, the mean scores were 46.00 for Group A, 47.50 for Group B, and 34.08 for Group C. To determine whether there was a statistically significant difference between the means of these groups, an ANOVA was performed (Table 3), and the difference between the groups for REVT expressive vocabulary was statistically significant ($F(2, 33)=9.370, p < .001$). For REVT receptive vocabulary, the mean scores were 38.92 for Group A, 42.92 for Group B, and 28.58 for Group C. There was a significant difference in receptive vocabulary scores between the speech sound acquisition groups ($F(2, 33)=11.990, p < .000$).

Regarding phonological processing by speech sound acquisition, the means of the nonword task were 4.17 for Group A, 3.75 for Group B, and 2.42 for Group C. There was a significant difference in nonword task scores between the groups ($F(2, 33) = 13.326, p < .000$). The mean score on the sentence task was 3.833 for Group A, 3.5 for Group B, and 2.5 for Group C, with a statistically significant difference between the speech production groups ($F(2, 33)=10.792, p < .000$).

In summary, groups A and B, with higher speech production skills, scored higher on average in vocabulary and phonological processing than Group C, with lower speech production skills. Significant differences were observed between the groups in expressive vocabulary, receptive vocabulary, nonword tasks, and sentence tasks.

Relationship between vocabulary and phonological processing skills by level of speech sound acquisition

The correlation analysis results for vocabulary and phonological processing skills in 3-year-old children, grouped by speech sound acquisition level, are shown in Table 4. Expressive and receptive vocabulary ($r = .757$, $p < .000$) and expressive vocabulary and sentence tasks

Table 2. Descriptive Statistics on Vocabulary & PPA by Group

Group	Variable	<i>M</i>	<i>SD</i>	<i>SE</i>
A (n=12)	Vocabulary	REVT - E	46.00	8.707
		REVT - R	38.92	8.597
	PPS	Nonword Repetition	4.17	1.030
		Sentence Repetition	3.833	.3892
B (n=12)	Vocabulary	REVT - E	47.50	5.901
		REVT - R	42.92	7.902
	PPS	Nonword Repetition	3.75	.866
		Sentence Repetition	3.500	.6742
C (n=12)	Vocabulary	REVT - E	34.08	9.848
		REVT - R	28.58	5.282
	PPS	Nonword Repetition	2.42	.669
		Sentence Repetition	2.500	1.0000

REVT-E=Receptive Expressive Vocabulary Test-Expressive score; REVT-R=Receptive Expressive Vocabulary Test-Receptive score; PPS=phonological processing skill.

Table 3. One-Way ANOVA on Vocabulary & PPA by Group

variable	SS	<i>df</i>	<i>MS</i>	<i>F</i>
Vocabulary	REVT - E	1297.056	2	648.528
	REVT - R	1312.889	2	656.444
PPS	Nonword Repetition	20.056	2	10.028
	Sentence Repetition	11.556	2	5.778

REVT-E=Receptive Expressive Vocabulary Test-Expressive score; REVT-R=Receptive Expressive Vocabulary Test-Receptive score; PPS=phonological processing skill.

Table 4. Pearson's Correlation Analysis for each Variable

variable	Vocabulary		PPA	
	REVT - E	REVT - R	Nonword Repetition	Sentence Repetition
Vocabulary	REVT - E	1	.178	.423**
	REVT - R	.757***	1	.440**
PPS	Nonword Repetition	.178	1	.568***
	Sentence Repetition	.423**	.568***	1

REVT-E=Receptive Expressive Vocabulary Test-Expressive score; REVT-R=Receptive Expressive Vocabulary Test-Receptive score; PPS=phonological processing skill.

($r = .423, p < .01$) showed positive, statistically significant correlations. Significant correlations were also found between receptive vocabulary and sentence tasks ($r = .440, p < .007$), and between nonword and sentence tasks ($r = .568, p < .000$). However, correlations between expressive vocabulary and nonword tasks ($r = .178, p < .298$) and between receptive vocabulary and nonword tasks ($r = .289, p < .087$) were not significant.

In summary, correlations between expressive and receptive vocabulary, expressive vocabulary and sentence tasks, receptive vocabulary and sentence tasks, and nonword and sentence tasks were positive and statistically significant.

Effects of the level of speech sound acquisition on vocabulary and phonological processing skills

To investigate whether the level of speech sound acquisition affected vocabulary and phonological processing skills, we conducted a logistic regression analysis. The results are shown in Table 5. Higher expressive vocabulary scores were statistically significant in Group A ($\beta = .152, p < .009$) and Group B ($\beta = .177, p < .011$). Higher receptive vocabulary scores were associated with Group A ($\beta = .264, p < .012$) and Group B ($\beta = .324, p < .003$), both statistically significant. Higher nonword task scores were associated with Group A ($\beta = 2.901, p < .012$) and Group B ($\beta = 2.393, p < .003$), and were statistically significant. Higher sentence task were associated with Group A ($\beta = 2.621, p < .005$) and Group B ($\beta = 1.445, p < .022$), also statistically significant.

Table 5. Logistic Regression between Groups & Variables

ABC ^z (z: reference category)		A	B
Vocabulary	REVT - E	.152**	.177**
	REVT - R	.264*	.324**
PPS	Nonword Repetition	2.901**	2.393*
	Sentence Repetition	2.621**	1.445*

PPS=phonological processing skill

In summary, using Group C as the reference for expressive vocabulary, receptive vocabulary, and nonword and sentence tasks, higher scores in each task significantly increased the probability of belonging to Groups A and B.

DISCUSSION

Phonological processing skills and vocabulary development are closely linked in early childhood. However, the influence of speech sound acquisition levels on these abilities in typically developing young children remains underexplored. This study aimed to obtain practical insights by exploring the relationship between vocabulary and phonological processing skills based on early speech sound acquisition in 3-year-old children. The results were as follows:

First, there were differences in vocabulary and phonological processing skills among 3-year-old children according to their level of speech sound acquisition. Groups A and B scored higher than Group C on all tasks, with significant differences between the groups. Compared to Groups A and B, Group C scored lowest on expressive and receptive vocabulary assessments. This finding demonstrates the close link between phonological and vocabulary development and aligns with previous research showing that phonological awareness and production can predict vocabulary size [17,18,33-35]. Phonological development plays an important role in vocabulary development; in particular, the list of phonemes a child has acquired influences word learning ability. These results support the idea that phonological awareness and articulation skills contribute to vocabulary expansion and show that individual phonemes acquired by children can lead to vocabulary differences. These results are consistent with studies reporting that a more sophisticated phonological system is associated with higher vocabulary and phonological processing [12,13,36-38]. Thus, children's

vocabulary may provide additional insights into the complex relationship between phonological awareness, speech production, and word learning. This study contributes to our understanding of how phonological and vocabulary development interact, and emphasizes the importance of speech sound recognition and acquisition in early speech and language development.

Compared to Groups A and B, Group C had the lowest mean scores on phonological processing task. Even after accounting for their level of speech sound acquisition, Group C performed lowest, with statistically significant differences from the other groups. These differences were most pronounced in the 4- and 5-syllable nonword tasks and in the sentence tasks with clauses. This suggests that children's phonological acquisition influences their ability to process phonological structures as syllables increase, and that nonword tasks may be effective for detecting subtle differences in phonological processing ability. Children with lower levels of speech sound acquisition appear significantly less able to process complex phonological structures, supporting theories that children in early speech and language development are sensitive to phonological unit size and syllable structure [39-43]. In the sentence task, 11 participants in Group A and 7 participants in Group B completed the four-sentence task, compared to only 3 in Group C. This difference was statistically significant, with Group A performing best and Group C worst in sentence tasks involving length and complexity, lexical variety, phonological awareness, and phonological memory. These findings suggest that phonological processing does not simply develop with age but is closely linked to each child's speech sound acquisition experience. Therefore, both levels of speech sound acquisition and phonological processing skills should be considered in developmental assessment and intervention planning.

Second, there were significant correlations between the vocabulary and phonological processing skills of typical 3-year-old children across speech sound acquisition lev-

els, particularly for expressive vocabulary and receptive vocabulary, expressive vocabulary and sentence tasks, receptive vocabulary and sentence tasks, and nonword tasks and sentence tasks.

The correlation between expressive and receptive vocabulary supports Martin and Saffran's assertion [44] that "input and output phonological abilities involved in receptive and expressive precision are functionally related," as also found in studies by Morrisett and Gierut and by Storkel and Morrisett [45,46]. This suggests that the ability to perceive and process phonology and the ability to produce phonological sounds accurately develop in a mutually influential manner; the ability to discriminate speech sounds affects the accuracy of pronunciation, and experience with accurate pronunciation improves phonological perception. This interaction plays an important role in the overall development of the phonological system and in language acquisition. In this study, there was a statistically significant correlation between expressive and receptive vocabulary. The correlation between expressive and receptive vocabulary and the sentence task is consistent with previous research showing that a larger vocabulary facilitates sentence comprehension and production, as phrases are part of the lexicon [47]. Sentence tasks are related to phonological processing, which involves better recall of words in context, and the phoneme inventory children produce [48]. Vocabulary contributes the ability to support words and linguistic contexts within sentences and to use phonological information, while phonological processing is linked to linguistic input and output, utterance length, and sentence complexity [49].

The correlation between nonword and sentence tasks indicates a link between phonological processing of novel phonological representations not present in the lexicon and sentence comprehension and production. In particular, performance on nonword tasks is influenced by articulatory motor planning and execution [50-52]. The process of recognizing and producing new phonemes is evaluated based on articulation accuracy, which reflects

the quality of phonological processing. Furthermore, phonological processing is closely related to speech sound acquisition, as argued by Van Kleeck et al. [48]. In the present study, Group C performed well on the nonword task for up to three syllables, a trend mirrored in the sentence task. These findings support prior research showing that phonological processing buffers language output, facilitating the use of longer, more diverse vocabulary and more complex sentences [48,53]. Therefore, the relationship between vocabulary and phonological processing should be considered integral to facilitating language development and intervention.

Third, the level of speech sound acquisition significantly influenced vocabulary and phonological processing in typical 3-year-old children. Higher expressive vocabulary scores and receptive vocabulary scores significantly increased the probability of belonging to groups A and B. These results suggest a close relationship between vocabulary and phonological representation development, indicating that children with a higher vocabulary are more likely to have more developed phonological systems. This is also consistent with existing research showing that a poor phonological system can lead to difficulties in word learning and vocabulary acquisition [16,19,54-56].

Phonological processing was linked to higher scores on nonword and sentence tasks, which also increased the probability of belonging to groups A and B. Hierarchical analysis revealed that performance on the four-syllable nonwords and four-sentence significantly increased the likelihood of belonging to Group A. These results suggest that differences in handling four-syllable nonwords and sentences with clauses can serve as a measure of phonological processing, indicating that children excelling in these tasks are more likely to score higher in speech sound acquisition. Thus, the ability to accurately store and produce phonological representations across syllables lengths, and to comprehend and produce complex sentences, is closely related to speech sound acquisition.

The results of this study are consistent with previous research showing that children with stronger phonological processing skills produce longer, more complex sentences than those with lower skills [53,57-59].

This study confirms that the phoneme inventory of 3-year-olds is closely related to their vocabulary learning and phonological processing, and that early differences in speech sound acquisition can lead to later differences in these skills [60]. These findings emphasize the need to account for speech sound acquisition levels when facilitating language development. In conclusion, children's speech sound acquisition plays an important role in their vocabulary and phonological processing abilities, with performance on complex phonological structures and sentences offering a useful predictor of speech sound acquisition level. This provides important guidance for language development assessment, intervention, and program development to support children's language growth.

One limitation of this study is its sample size, of 12 children per group, which limits statistical power and limits the generalizability of the findings. A follow-up study with more participants is required to increase reliability. Furthermore, given the age-specific nature of speech sound acquisition, the lack of fine-grained task types and the omission of other important factors (e.g., articulatory system structure and function, auditory processing ability, cognitive ability) may also affect results. To overcome these limitations, future studies should employ larger samples, more granular tasks, and incorporate additional factors influencing speech sound development.

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