

Original Article

Comparison of Speech Processing in Children with Articulation and Phonological Disorders and Typically Developing Children

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Purpose This study aimed to compare speech processing between typically developing children and those with articulation and phonological disorders by examining performance across three stages: input, lexical representations, and output.

Methods The participants consisted of 33 typically developing children and 23 children with articulation and phonological disorders, aged 4 to 6. According to the speech processing model, three tasks were carried out: a phonetic discrimination task, a phonological representation judgment task, and a nonword repetition task. Independent *t*-tests, mixed-design ANOVAs, and Pearson correlations were conducted.

Results The results indicated no significant differences between the groups in the phonetic discrimination task. However, in the phonological representation judgment task, typically developing children performed significantly better than those with articulation and phonological disorders ($p < .001$). In the nonword repetition task, both groups displayed decreased performance as syllable length increased. Typically developing children consistently outperformed the other group in all syllable conditions ($p < .001$). Correlation analysis revealed a significant positive relationship between phonetic discrimination and phonological representation judgment, but no significant correlation was found with nonword repetition.

Conclusions The findings indicate that difficulties experienced by children with articulation and phonological disorders may not stem from how they perceive speech input, but rather from weaknesses in their phonological representation and speech programming. This study underscores the importance of assessing speech processing at various stages to guide personalized clinical interventions.

Keywords articulation and phonological disorders, phonetic discrimination task, phonological representation judgment task, nonword repetition task, speech processing

INTRODUCTION

Articulation and Phonological Disorders can lead to challenges in spoken communication, as these conditions result in ongoing difficulties with speech production. This occurs even when there are no structural, neurological, or linguistic impairments affecting the anatomical mechanism involved [1]. Several theories have been proposed to explain the causes of these speech production issues. One such theory is a psycholinguistic approach that aims to identify the underlying factors con-

tributing to the problem. Additionally, there is a classification system based on observable error patterns in speech [2,3]. In clinical practice, attempts have been made to classify articulation and phonological disorders into subtypes based on the patterns and consistency of speech sound errors. While this classification can be helpful for diagnosis and intervention, it tends to emphasize surface characteristics rather than addressing the underlying features of these disorders [4]. In contrast, the psycholinguistic approach, based on the speech processing model [2], explains speech production as a process

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comprised of input, lexical representation, and output stages. This model explicitly illustrates the process from children perceiving and distinguishing sounds to utilizing phonological knowledge stored in their vocabulary to plan and manipulate speech movements, and ultimately producing speech sounds. Therefore, children with articulation and phonological disorders may experience difficulties in one or more of these speech processing stages, leading to problems with speech production [5,6]. Speech processing can be broadly categorized into three stages. The first stage, known as the input stage, involves the discrimination and perception of speech sounds. Children with articulation and phonological disorders typically do not face significant challenges with phonetic discrimination. However, they may struggle to discriminate specific phonemes where errors occur [7,8]. This ability to discriminate phonemes is crucial for the subsequent stages of speech processing and can be assessed through phonetic discrimination tasks that utilize both meaningful and nonword stimuli [9]. Second, the lexical representation stage is the process of storing phonological information of words in long-term memory [10]. Children aged 4 to 6 undergo rapid development of phonological representations during this period [11,12]. Well-developed phonological representations contain both auditory and visual information about words, enabling their recognition and discrimination [2]. However, children with articulation and phonological disorders exhibit difficulties in speech production due to unclear access to phonological representations [13]. This process can be evaluated through phonological representation judgment tasks, which reduce the burden of the oral output and allow phonological representations to be examined solely through receptive abilities while minimizing the demands of speech production [14-16].

The final stage of speech development is the process of speech programming. This can be evaluated using a nonword repetition task, in which children listen to spoken words and are asked to repeat them accurately.

Performance on this task is affected by two main factors: the number of syllables in the words and their similarity to one another. As the number of syllables increases, the cognitive load on children becomes greater. Additionally, when the words are less similar, it minimizes the influence of semantic understanding, allowing for a more precise assessment of the children's speech programming abilities [17]. This study aims to investigate the differences between children with articulation and phonological disorders and typically developing children by comparing their characteristics across three stages of speech processing: input, lexical representations, and output.

METHODS

Participants

This study included 33 typically developing children aged 4 years 0 months to 6 years 11 months and 23 children with articulation and phonological disorders. All participants were reported by their parents or teachers to have no sensory, neurological, physical, cognitive, or linguistic impairments, and no structural abnormalities of the articulatory organs. Additionally, their receptive vocabulary abilities were above -1 SD on the Receptive & Expressive Vocabulary Test [18]. Based on the results of the Urimal Test of Articulation and Phonology 2 [19], the children were classified.

The classification results showed no statistically significant differences in chronological age or receptive vocabulary between typically developing children and children with articulation and phonological disorders ($p > .05$). In contrast, the typically developing group demonstrated significantly higher consonant accuracy ($p < .001$). The statistical characteristics of the participants are presented in Table 1.

Table 1. Differences in Equivalent Age, Receptive Vocabulary Age, and Consonant Accuracy between Groups

Group	Chronological Age (Months)	Receptive Vocabulary Age (Months)	Percentage of Correct Consonants (%)
Typically Developing Children (N = 33)	66.70 (5.97)	79.67 (15.30)	98.99 (1.29)
Children with Articulation and Phonological Disorders (N = 23)	64.04 (10.11)	71.87 (20.26)	83.51 (10.34)
<i>t</i>	1.129	1.561	7.143***

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

Research tasks

In this study, the speech processing model [2] was employed to divide the speech processing process into three stages: input, lexical representation, and output. Experimental tasks were selected and developed accordingly: the phonetic discrimination task for the input stage, the phonological representation judgment task for the lexical representation stage, and the nonword repetition task for the output stage.

The phonetic discrimination task involved meaningful and nonword minimal pairs that differed by only one feature—voicing, place of articulation, or manner of articulation. For each condition, five target words were selected and developed. The test words included CV, CVCV, and CVCCVC structures, totaling 40 stimulus pairs. Each contrast was represented by two pairs of correct productions and two pairs of misarticulations. Scoring was straightforward, with 1 point awarded for each correct response and 0 points for each incorrect one, leading to a maximum possible score of 40. The phonological representation judgment task included eight trisyllabic words. For each word, eight minimal pairs were created by altering consonants and vowels to contrast specific features. Each word was presented with three auditory stimuli; one correct response and two incorrect responses, resulting in a total of 24 items. Participants received one point for each correct response and zero points for each incorrect response, with a maximum possible score of 24. The nonword repetition task was designed primarily to examine phonological processing rather than assess articulatory ability. Given the typical

consonant acquisition level of children aged 4 to 6, only early-developing phonemes—such as nasals, plosives, and affricates—were included [20]. The task consisted of 15 items: five three-syllable items, five four-syllable items, and five five-syllable items, all featuring low word similarity. Each syllable was constructed with a consistent consonant-vowel (CV) structure. Responses were analyzed at the syllable level, earning 1 point assigned for each correct production and 0 points for each misarticulation, resulting in a total maximum score of 60.

Research procedure

This study on speech processing consisted of three stages—input, lexical representations, and output. The stimuli for this study were produced in standard Korean pronunciation by a woman in her 30s. To ensure that the auditory stimuli were accurately perceived as intended target stimuli, task validation was conducted with five certified level-1 speech-language pathologists. Additionally, all stimuli were set to an intensity of 80 dB. In the phonetic discrimination task and the phonological representation judgment task, children's responses were gathered using O and X cards. In the nonword repetition task, children were instructed to repeat the stimulus words after hearing them. Their responses were recorded and analyzed by three certified level-1 speech-language pathologists to ensure the reliability of the analysis. Before administering the test, practice items were provided to ensure that the children fully understood the tasks. The stimuli were presented in a random order to prevent them from learning specific patterns. If a child lost focus,

did not respond, or requested to hear the stimulus again, it was replayed only once.

Data processing and analysis

In this study, we examined the speech processing of the Typically Developing group and the Children with Articulation and Phonological Disorders group. Analyses were conducted using *SPSS Statistics version 18.0*, following the procedures outlined below. First, independent-samples *t*-tests were conducted to compare the task score differences between the Typically Developing group and the Children with Articulation and Phonological Disorders group. Furthermore, mixed-design ANOVAs were performed to examine within-group differences under each task condition and to identify interaction effects. Post-hoc analyses for the main effects were carried out using the Bonferroni test, and Pearson correlation analyses were performed to explore the relationships among the tasks. To evaluate the validity of the research tasks, five certified level-1 speech-language pathologists, each with over 10 years of clinical experience, were involved. A 5-point Likert Scale was used for the validity assessment. The results indicated a score of 4.8 for the phonetic discrimination task, 4.4 for the phonological representation judgment task, and 4.4 for the nonword repetition task. To assess the inter-rater reliability of the nonword repetition task, three certified level-1 speech-language pathologists with more than 5 years of clinical experience participated. Twenty percent of the target children were randomly se-

lected for evaluation, and the inter-rater reliability was determined to be 0.97.

RESULTS

Phonetic discrimination

An independent-samples *t*-test was conducted to evaluate the phonetic discrimination performance of the Typically Developing group compared to the Children with Articulation and Phonological Disorders group. The results indicated that there was no statistically significant difference in phonetic discrimination performance between the two groups ($p > .05$). The detailed results are presented in Table 2. To compare performance differences according to task conditions, a mixed-design ANOVA was conducted. The results showed that neither the main effect of group ($F(1, 54) = 3.763, p > .05$) nor the main effect of condition ($F(1, 54) = 0.057, p > .05$) was statistically significant. Furthermore, the interaction effect between group and condition was found to be non-significant ($F(1, 54) = 0.764, p > .05$). The detailed

Table 2. Results of the Phonetic Discrimination Task between Groups

	N	Mean (SD)	<i>t</i>
Typically Developing Children	33	35.42 (3.64)	1.940
Children with Articulation and Phonological Disorders	23	33.43 (3.96)	

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

Table 3. Results of Repeated-Measures ANOVA for the Phonetic Discrimination Task

	Sum of Squares	df	Mean Square	<i>F</i>	<i>p</i>
<i>Between Groups</i>					
Group	26.822	1	26.822	3.763	.058
Error	384.856	54	7.127		
<i>Within Groups</i>					
Task Condition	.286	1	.286	.057	.812
Group × Task Condition	3.822	1	3.822	.764	.386
Error	270.142	54	5.003		

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

results can be found in Table 3.

There were no differences in phonetic discrimination performance between the Typically Developing group and the group of Children with Articulation and Phonological Disorders.

Phonological representation judgment

An independent-samples *t*-test was conducted to examine the phonological representation judgment performance of two groups: the Typically Developing group and the Children with Articulation and Phonological Disorders group. The results revealed a statistically significant difference between the two groups ($p < .001$), with the Typically Developing group showing significantly higher performance than the Children with Articulation and Phonological Disorders group. The detailed results are presented in Table 4.

Nonword repetition

An independent-samples *t*-test was conducted to examine the nonword repetition performance between the

Typically Developing group and the Children with Articulation and Phonological Disorders group. The findings revealed a statistically significant difference between these two groups ($p < .001$), with the Typically Developing group exhibiting significantly superior performance compared to the Children with Articulation and Phonological Disorders group. The detailed results are presented in Table 5.

To evaluate performance variations based on task conditions, a mixed-design ANOVA was conducted, utilizing three-, four-, and five-syllable words as within-subject factors, while the Typically Developing group and the Children with Articulation and Phonological Disorders group served as between-subject factors. Given that the assumption of sphericity was not satisfied, the Greenhouse-Geisser correction was employed to adjust the degrees of freedom for both the main effect of condition and the interaction effect between group and condition. The results are summarized in Table 6. The analysis identified a statistically significant main effect of group ($F(1, 54) = 20.877, p < .001$), as well as a significant main effect of condition ($F(1.709, 92.272) = 20.279, p < .001$). The Bonferroni post-hoc test indicated that the Typically

Table 4. Results of the Phonological Representation Judgment Task between Groups

	N	Mean (SD)	<i>t</i>
Typically Developing Children	33	22.58 (1.37)	4.455***
Children with Articulation and Phonological Disorders	23	18.74 (3.97)	

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

Table 5. Results of the Nonword Repetition Task between Groups

	N	Mean (SD)	<i>t</i>
Typically Developing Children	33	50.36 (5.46)	4.022***
Children with Articulation and Phonological Disorders	23	40.57 (10.76)	

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

Table 6. Results of Repeated-Measures ANOVA for the Nonword Repetition Task

	Sum of Squares	df	Mean Square	<i>F</i>	<i>p</i>
<i>Between Groups</i>					
Group	10805.804	1	10805.804	20.877	.000***
Error	24949.809	54	517.589		
<i>Within Groups</i>					
Task Condition	3555.154	1.709	2080.560	20.279	.000***
Group × Task Condition	104.212	1.709	60.987	.594	.528
Error	9467.014	92.272	102.599		

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

Developing group significantly outperformed the Children with Articulation and Phonological Disorders group ($p < .001$). Performance on three-syllable words surpassed that of four- and five-syllable words, and performance on four-syllable words exceeded that of five-syllable words ($p < .001$). Conversely, the interaction effect between group and condition did not achieve statistical significance ($F(1.709, 92.272) = 0.574, p > .05$). The performance of groups in relation to task conditions is illustrated in Figure 1.

Correlation

Pearson correlation analyses were conducted to examine the relationships among the phonetic discrimination,

phonological representation judgment, and nonword repetition tasks, with the findings summarized in Table 7. The analysis revealed a significant positive correlation between phonetic discrimination and phonological representation judgment in both the Typically Developing group and the Children with Articulation and Phonological Disorders group ($p < .05$). Conversely, no statistically significant correlations were identified between phonetic discrimination and nonword repetition, or between phonological representation judgment and nonword repetition ($p > .05$).

DISCUSSION AND CONCLUSION

This study conducted a comparative analysis of the input, lexical representations, and output stages involved in speech processing among typically developing children and children diagnosed with articulation and phonological disorders, specifically within the 4- to 6-year age group. The analysis utilized tasks focused on phonetic discrimination, phonological representation judgment, and nonword repetition.

In the phonetic discrimination task, which assessed the input stage, the Typically Developing group achieved a mean score of 35.42, whereas the Children with Articulation and Phonological Disorders group obtained a mean score of 33.43. Although the Typically Developing group outperformed their counterparts, the difference in scores was not statistically significant. This finding aligns with previous studies that have reported no discernible

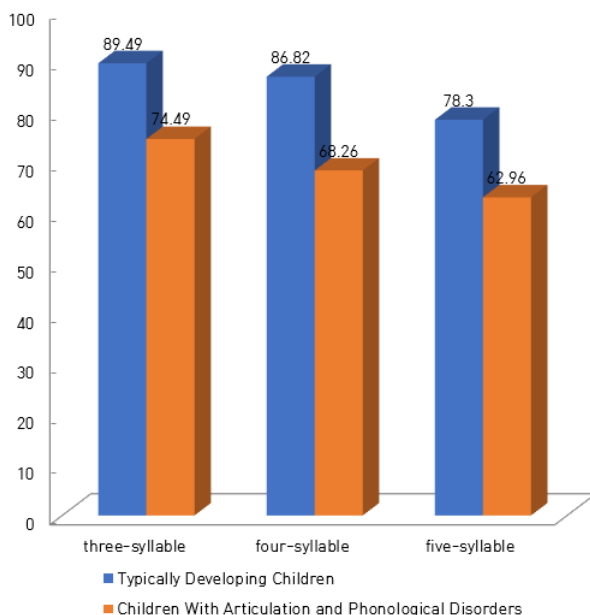


Figure 1. Nonword Repetition Performance by Number of Syllables

Table 7. Results of Correlation Analysis among Speech Processing Tasks

	Phonetic Discrimination and Phonological Representation Judgment	Phonetic Discrimination and Nonword Repetition	Phonological Representation Judgment and Nonword Repetition
Typically Developing Children	.377*	.213	.051
Children with Articulation and Phonological Disorders	.367*	.210	.052

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

differences in phonetic discrimination performance between typically developing children and those with articulation and phonological disorders [21-23]. These results suggest that children with articulation and phonological disorders may demonstrate auditory perception abilities for discriminating speech sounds that are comparable to those of typically developing children. Moreover, their reduced articulatory skills suggest that the challenges they face may not stem from phonetic discrimination deficits, but rather from potential impairments in subsequent stages, such as phonological representation or speech programming. The phonetic discrimination task was subsequently analyzed for both meaningful and nonword stimuli. The Typically Developing group achieved a mean score of 17.85 for meaningful words and 17.58 for nonwords. In contrast, the Children with Articulation and Phonological Disorders group recorded a mean score of 16.48 for meaningful words and 16.96 for nonwords, indicating no significant differences in performance between the groups. Discrimination of meaningful words engages a top-down processing pathway that is predicated on higher-level semantic representations. Generally, top-down processing, which incorporates semantic representations, is associated with enhanced performance compared to bottom-up processing that relies solely on simple stimuli without meaning [9]. However, the absence of performance differences observed in this study indicates that the presence or lack of semantic information does not distinctly influence phonetic discrimination performance. Upon examination of the lexical representations stage via the phonological representation judgment task, the Typically Developing group exhibited a mean score of 22.58. In contrast, the Children with Articulation and Phonological Disorders group attained a mean score of 18.74. This difference is statistically significant, highlighting a notable disparity between the two groups. This result is consistent with previous studies, which report that children with articulation and phonological disorders display lower performance in phono-

logical representation abilities compared to typically developing children [13,14,24]. While phonetic discrimination refers to the ability to perceive and distinguish incoming speech sounds rapidly, phonological representations refer to the ability to retrieve speech sound information quickly and accurately from long-term memory. Accurate speech production often necessitates a well-established phonological representation. However, research indicates that children diagnosed with articulation and phonological disorders demonstrate a diminished ability in phonological representation, suggesting that their phonological constructs may not be adequately developed. Furthermore, this could imply that the interconnections between these representations are not functioning optimally.

In the nonword repetition task, which examined the output stage, the Typically Developing group had a mean score of 50.36, while the Children with Articulation and Phonological Disorders group had a mean score of 40.57, showing a difference of approximately 10 points. This difference was statistically significant. These results align with previous studies indicating that children with articulation and phonological disorders show poor performance on nonword repetition tasks [13,14,22,24,25]. Furthermore, both groups showed a tendency for performance to decline as the number of syllables increased. The Children with Articulation and Phonological Disorders group showed significantly lower performance than the Typically Developing group across all syllable lengths. This finding highlights the overall vulnerability of children with articulation and phonological disorders in these tasks. The nonword repetition task requires children to temporarily retain the incoming phonological information, integrate it, and produce it in the correct sequence. This process demands complex speech processing abilities, including phonetic discrimination, phonological representations, and speech motor planning. Therefore, the facts that not only children with articulation and phonological disorders—who showed lower performance in phonological representation—but also

typically developing children with relatively adequate phonological representations exhibited decreased performance as syllable length increased suggests that speech programming ability may reflect higher-order integrated speech production skills, such as working memory, rather than being explained solely by the accuracy of phonological representations [26,27].

Correlation analyses among the three tasks revealed a significant positive correlation between the phonetic discrimination and phonological representation judgment tasks in both Typically Developing Children and Children with Articulation and Phonological Disorders. These results support the speech processing model [2], which suggests that the ability to perceive and discriminate incoming speech sound stimuli accurately is fundamental for storing phonological information as structured phonological representations in long-term memory. In simpler terms, better phonetic discrimination ability leads to more accurate and robust phonological representations, indicating that these two processes are interdependent rather than operating independently. In contrast, no significant correlations were found between the phonetic discrimination and nonword repetition tasks, nor between the phonological representation judgment and nonword repetition tasks. Nonword repetition may be influenced not only by perceptual or phonological representation abilities but also by the precise coordination of oral structures, such as the lips and tongue [28].

Speech processing may follow a sequence of stages—input, lexical representations, and output—but it can also function independently at each stage. Reduced oral motor function may not affect phonetic discrimination or phonological representation abilities, but it can impact speech programming. Moreover, while a child may accurately produce a word, they could still struggle with perceiving or discriminating it [2,13]. This perspective underscores the finding that phonetic discrimination and phonological representation were not correlated with speech programming. It suggests that difficulties in

speech production may occur independently of input and lexical representation stages. Therefore, challenges in speech production do not necessarily indicate deficits in phonetic discrimination or phonological representation, which carry significant clinical implications.

This study holds significance as it evaluates the overall speech processing of children with articulation and phonological disorders from a psycholinguistic perspective, categorizing it into input, lexical representations, and output stages. Specifically, by designing tasks that correspond to each stage and analyzing both the independence and interrelationships among these stages of speech processing, the study indicates that the deficits in speech production among children with articulation and phonological disorders may not come from a singular cause. This finding bears clinical importance, as it allows for a more accurate diagnosis of the speech processing characteristics in this population, thereby facilitating the development of individualized intervention strategies that adopt stage-specific approaches.

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