

Original Article

Comparison of Phonological Representation Judgment Performance Across Subtypes of Articulation and Phonological Disorders

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Purpose This study compared phonological representation judgment performance among typically developing children and children with articulation disorder, phonological delay, and phonological disorder in both chronological-age-matched and language-age-matched groups. It also examined performance across consonant- and vowel-manipulation conditions and according to developmental and non-developmental error types in consonant-manipulated stimuli.

Methods A total of 106 children aged 4-6 years (71 typically developing children and 35 children with articulation and phonological disorders) participated. Children with articulation and phonological disorders were classified as having an articulation disorder ($n = 10$), a phonological delay ($n = 11$), or a phonological disorder ($n = 14$). Chronological age-matched ($n = 82$) and language age-matched ($n = 77$) groups were formed from the participants, who completed a phonological representation judgment task comprising consonant- and vowel-manipulated stimuli.

Results In the chronological age-matched group, typically developing children outperformed children with phonological disorders in overall task performance and specifically in the consonant-manipulation condition. However, no significant differences between the groups were found in the language age-matched group. In both matched groups, performance was better in the vowel-manipulation condition compared to the consonant-manipulation condition. Additionally, no distinct performance patterns were observed based on developmental and non-developmental error types.

Conclusions Phonological representation judgment performance may vary according to subtype and level of language development rather than constitute a fixed characteristic of articulation and phonological disorder subtypes. Results regarding error types should be considered exploratory.

Keywords Articulation and phonological disorders, phonological representations, phonological representation judgment task, developmental error types, non-developmental error types

INTRODUCTION

The causes of speech sound errors in children with articulation and phonological disorders are varied, making them challenging to identify and define clearly. Some children exhibit errors that are limited to specific phonemes, while others display speech sound errors that are common during typical development. Additionally, some children demonstrate error patterns that are not typically

observed in normal development [1]. The forms and severity of these speech sound errors may reflect the complex interaction of biological, environmental, and linguistic factors [2-4]. Rather than viewing children with articulation and phonological disorders as a homogeneous group, it is crucial to consider the different perspectives used to explain speech sound errors and to recognize subtype-specific characteristics [5].

There are various approaches to explaining speech

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sound errors, which include classification systems based on the causes of these errors, linguistic approaches that focus on the types of surface errors, and psycholinguistic approaches that examine the underlying processes involved in speech production [1,6,7]. Among these, the psycholinguistic approach looks at how difficulties at different stages of speech perception and production may lead to these errors. This perspective goes beyond just observing the symptoms; it also considers the fundamental processes involved in perceiving, storing, and producing speech information [2,7-9].

The psycholinguistic model of speech processing [7] conceptualizes speech perception and production as involving three main components: input processing, lexical representations, and output processing. Lexical representations encompass both semantic and phonological information. Speech sound errors in children with articulation and phonological disorders may stem from weaknesses in any of these components—input processing, lexical representations, or output processing—as well as from the interactions among them [2,7]. Phonological representations refer to how speech sound information is stored and organized within lexical representations in long-term memory. Early in development, these representations are relatively holistic and based on whole words. As a child's vocabulary expands and they gain experience with words that have similar phonological structures, these representations become more detailed and specified at the syllable and phoneme levels [10-12]. Well-developed phonological representations facilitate speech sound recognition and discrimination, support stable phonological development, and lead to accurate speech production [2,7,8,12,13].

One effective method for examining phonological representations is through a phonological representation judgment task [9,14,15]. In this task, children are asked to determine whether a spoken stimulus, presented with a picture, matches the target word. This approach does not require overt speech production, allowing researchers

to investigate how children utilize stored phonological information to compare and assess phonological differences between target words and spoken stimuli, while minimizing the demands of speech production [14,16,17]. Additionally, the task can also involve conditions that manipulate consonants and vowels by changing the initial consonant or vowel in the target words. This manipulation enables researchers to observe how children compare and judge alterations in consonants and vowels, respectively [14,18,19].

Previous studies using phonological representation judgment tasks have reported poorer performance in children with articulation and phonological disorders than in typically developing children [9,15,17]. Notably, poorer performance on a task that does not directly require speech production implies that difficulties with speech sounds may involve not only overt production issues but also processes involved in accessing, comparing, and judging phonological information within lexical representations. Furthermore, a study comparing consonant- and vowel-manipulation conditions revealed that both typically developing children and those with articulation and phonological disorders exhibited lower performance in the consonant-manipulation condition [20]. These findings suggest that consonant and vowel manipulations impose different demands on phonological discrimination. Therefore, when examining the phonological representation judgment performance of children with articulation and phonological disorders, it is crucial to consider not just their overall performance but also their performance in consonant- and vowel-manipulation conditions.

Previous studies indicate that children with articulation and phonological disorders may face greater challenges in phonological representation judgment than typically developing children. Additionally, their performance might vary depending on different manipulation conditions. However, most previous research has treated children with these disorders as a single group when making comparisons to typically developing children. Since these chil-

dren may exhibit different types and severities of speech sound errors, as well as various underlying factors contributing to those errors, it is essential to examine the performance of specific subtypes. Children with articulation and phonological disorders can be categorized based on their speech sound error patterns into three groups: articulation disorder, phonological delay, or phonological disorder [1]. Research has also shown that there are differences in the underlying processing characteristics associated with speech sound errors among these subtypes [21,22]. In addition, phonological representations become increasingly differentiated and refined as vocabulary develops [10-12], and performance on phonological representation judgment tasks may be influenced not only by chronological age but also by the child's level of language development [23,24]. Therefore, comparisons of phonological representation judgment performance across subtypes should account for group differences in chronological age and language development.

To examine performance in the consonant-manipulation condition in greater detail, it is essential to consider the error types represented in consonant-manipulated stimuli. Previous studies on phonological representation judgment have utilized consonant-manipulated stimuli that were phonologically similar to target words. However, approaches that classify the error forms of consonant-manipulated stimuli as developmental or non-developmental and analyze performance accordingly have been limited. Therefore, it is necessary to examine how children access and judge phonological information in stimuli manipulated to reflect different error types and whether these performance patterns vary across subtypes of articulation and phonological disorders.

Accordingly, this study classified children with articulation and phonological disorders into three subtypes: articulation disorder, phonological delay, and phonological disorder. Phonological representation judgment performance was compared across these subtypes using separate chronological-age-matched and language-age-matched

groups. This allowed us to examine whether differences in phonological representation judgment performance across subtypes varied according to the matching condition. The study also examined performance across consonant- and vowel-manipulation conditions and, within the consonant-manipulation condition, according to developmental and non-developmental error types represented in the consonant-manipulated stimuli. This approach extends previous research that treated children with articulation and phonological disorders as a single group by jointly considering subtype, matching condition, and error type, and may provide a basis for interpreting phonological representation judgment performance in the assessment of these children.

METHODS

Participants

This study involved 106 children aged 4-6 years: 71 typically developing children and 35 children with articulation and phonological disorders. According to reports from parents and teachers, all participants had no sensory, neurological, physical, or cognitive impairments and no structural abnormalities in their speech mechanisms.

Typically developing children were included if they scored at or above -1.5 standard deviations (SD) on the word-level test of the Urimal Test of Articulation and Phonology-2 (U-TAP2) [25] and at or above -1 SD on the receptive vocabulary test of the Receptive & Expressive Vocabulary Test (REVT) [26]. Children with articulation and phonological disorders were selected if they scored below -1.5 SD on the word-level test of the U-TAP2. No separate selection criterion based on REVT scores was applied to children with articulation and phonological disorders. Receptive vocabulary ability was used as the matching variable for forming the language-age-matched group.

Children with articulation and phonological disorders were further classified by their speech sound error patterns into 10 with articulation disorder, 11 with phonological delay, and 14 with phonological disorder. The articulation disorder group comprised children who showed distortion or substitution errors on specific speech sounds, such as the fricative /s/ or the liquid /l/, whereas the phonological delay group comprised children who exhibited only developmental error patterns. The phonological disorder group comprised children who exhibited both non-developmental and developmental error patterns [1]. Specifically, the non-developmental error patterns observed in children with phonological disorder included place-of-articulation errors, such as velarization and glottalization, and phonation errors, such as aspiration and laxing.

To compare phonological representation judgment performance across subtypes of articulation and phonological disorders, chronological-age-matched and language-age-matched groups were formed from all participants. The chronological-age-matched group was formed so that chronological age did not differ significantly across groups, whereas the language-age-matched group was formed so that receptive vocabulary age did not differ significantly across groups. Participants included in both matched groups comprised 51 typically developing children, 6 children with articulation disorder, 5 children with phonological delay, and 5 children with phonological disorder. The distribution of participants is presented in Table 1.

The chronological age-matched group comprised 82 children: 58 typically developing, 6 with articulation dis-

order, 7 with phonological delay, and 11 with phonological disorder. One-way analyses of variance (ANOVAs) were conducted to examine group differences in chronological age, receptive vocabulary age, and Percentage of Consonants Correct (PCC). The groups did not differ significantly in chronological age but did differ significantly in receptive vocabulary age and PCC. Specifically, the phonological disorder group had a significantly lower receptive vocabulary age than the typically developing and articulation disorder groups. The typically developing and articulation disorder groups had significantly higher PCC than the phonological delay and phonological disorder groups, while the phonological delay group had significantly higher PCC than the phonological disorder group. Participant characteristics are presented in Table 2.

The language age-matched group comprised 77 children: 55 typically developing, 9 with articulation disorder, 7 with phonological delay, and 6 with phonological disorder. One-way ANOVAs showed no significant group differences in receptive vocabulary age, whereas significant differences were observed in chronological age and PCC. Specifically, the articulation disorder group had a significantly higher chronological age than the typically developing and phonological delay groups. The typically developing group had significantly higher PCC than the articulation disorder, phonological delay, and phonological disorder groups. In contrast, the phonological delay and phonological disorder groups had significantly lower PCC than the articulation disorder group. Participant characteristics are presented in Table 3.

Table 1. Participant Distribution by Group

Group	Overall(N)	CA-Matched(N)	LA-Matched(N)
Typically Developing Children	71	58	55
Articulation Disorder	10	6	9
Phonological Delay	11	7	7
Phonological Disorder	14	11	6
Total	106	82	77

CA = chronological age; LA = language age.

Table 2. Participant Characteristics of the Chronological Age-Matched Group

Group	N	CA(months)	REVT-R(months)	PCC(%)
Typically Developing Children	58	65.53(5.90)	74.68(15.03)	98.12(3.18)
Articulation Disorder	6	69.67(4.03)	74.00(13.90)	92.71(2.87)
Phonological Delay	7	64.43(5.62)	66.80(15.00)	83.02(8.34)
Phonological Disorder	11	66.27(7.60)	51.45(20.44)	70.83(15.45)
<i>F</i>		1.001	6.722	57.878
<i>P</i>		.397	< .001***	< .001***

Values are presented as mean (SD).

CA = chronological age; REVT-R = Receptive and Expressive Vocabulary Test-Receptive (Kim et al., 2009); PCC = Percentage of Consonants Correct(%)

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

Table 3. Participant Characteristics of the Language Age-Matched Group

Group	N	CA(months)	REVT-R(months)	PCC(%)
Typically Developing Children	55	66.09(6.32)	75.25(13.64)	97.98(3.71)
Articulation Disorder	9	74.44(7.89)	75.22(11.39)	92.82(2.78)
Phonological Delay	7	60.71(6.63)	66.57(12.31)	80.34(8.12)
Phonological Disorder	6	66.67(9.07)	67.50(14.32)	79.17(12.22)
<i>F</i>		5.927	1.379	43.762
<i>P</i>		.001**	.256	< .001***

Values are presented as mean (SD).

CA = chronological age; REVT-R = Receptive and Expressive Vocabulary Test-Receptive (Kim et al., 2009); PCC = Percentage of Consonants Correct(%)

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

Phonological Representation Judgment Task

The phonological representation judgment task used in this study required children to determine whether an auditory stimulus presented alongside a picture matched the target word. This task was adapted and refined from a previous study to align with the objectives of the current research [9]. The eight target words used in the task were three-syllable nouns selected so that the initial consonant and initial vowel could each be manipulated while preserving the phonological structure of each target word. By eliminating the need for spoken responses, the task was designed to minimize speech production demands while reflecting the processing demands involved in accessing phonological information stored in long-term memory and comparing and judging the auditory stimulus against the target word. Manipulating the initial phoneme of a target word allows for the assessment of sensi-

tivity to subtle phonological differences. In addition, because vowels have relatively greater acoustic energy than consonants, they may provide important cues during the perception and judgment of phonological information. Moreover, the separate manipulation of consonants and vowels allows for a more detailed examination of the varying patterns in how phonological information is processed [14,16,18].

Accordingly, consonant-manipulated stimuli were created by altering only one feature of the initial consonant, place of articulation, manner of articulation, or phonation type, while maintaining phonological similarity to the target word, as in /pifangi/→[tɪfangi] and /tɛadoŋtʰa/→[tadoŋtʰa]. Consonant-manipulated stimuli were further categorized as developmental or non-developmental according to the type of error introduced. Of the eight consonant-manipulated stimuli, two represented developmental error types and six represented non-developmental error

types. Developmental error types included affricate stopping (/tɕadɔŋtɕʰa/→[tadɔŋtɕʰa]) and tensing (/sobanɕtɕʰa/→[s*obanɕtɕʰa]). Non-developmental error types included delabialization (/pifiŋgi/→[tifiŋgi]), aspiration (/tɕadzʌŋgʌ/→[tɕʰadzʌŋgʌ]), denasalization (/mokʰt*ori/→[pokʰt*ori]), and labialization (/nɛŋdʒʌŋgo/→[mɛŋdʒʌŋgo]). Vowel-manipulated stimuli were created by changing the first vowel of a target word to an adjacent vowel along either the front-back or height dimension, while maintaining phonological similarity to the target word, as in /tɕadɔŋtɕʰa/→[tɕʌdɔŋtɕʰa] and /mokʰt*ori/→[mukʰt*ori].

The phonological representation judgment task was designed to be completed in approximately 10 minutes, accounting for the children's age and task demands. Specifically, the task included eight target words, each accompanied by one consonant-manipulated stimulus and one vowel-manipulated stimulus, yielding a total of 24 items.

Procedure

Data were collected through visits to kindergartens, private speech-language therapy clinics, and similar settings. All assessments were administered using a laptop computer in separate, quiet rooms with minimal external noise. Auditory stimuli were presented at a consistent intensity.

The auditory stimuli were recorded in a sound-attenuated booth with professional recording equipment by a Korean female speaker in her thirties, who spoke with standard pronunciation. During recording, speech rate and intensity were kept constant so that differences between target words and manipulated stimuli were limited to phonological distinctive features. The auditory stimuli were digitized using Microsoft PowerPoint and programmed to be presented together with picture stimuli.

Before starting the main task, two practice items were administered to ensure that the children understood the procedure and how to respond. These practice items included both matching and non-matching picture-audi-

tory stimulus pairs, allowing the children to experience both types of responses. The examiner instructed the children, "Point to the O symbol if the picture and the word you hear match, and point to the X symbol if they do not." The main task was conducted after confirming that each child understood the response procedure.

The main task items were presented in a randomized order to prevent children from learning a specific response pattern. For each item, the picture and the auditory stimulus were presented simultaneously. The children listened to the auditory stimulus and indicated whether it matched the picture by pointing to the O/X response board. If a child did not respond or became inattentive during the task, the same stimulus was presented again, but only once.

Statistical Analysis

Statistical analyses were conducted using SPSS Statistics version 31.0 (IBM Corp., Armonk, NY, USA). First, separate one-way ANOVAs were performed for both the chronological age-matched and language age-matched groups to examine differences in total phonological representation judgment task scores across subtypes, as well as performance in the consonant- and vowel-manipulation conditions. When the assumption of homogeneity of variance was met, Tukey's post hoc test was applied. If this assumption was not met, Welch's ANOVA was utilized instead.

Next, two separate two-way mixed-design ANOVAs were conducted to analyze performance differences between the consonant- and vowel-manipulation conditions and to explore differences according to error type within the consonant-manipulation condition. Within the consonant-manipulation condition, performance for developmental and non-developmental error types was assessed by calculating percentage correct and *d'* values. For each error type, a hit was defined as a "match" response to a matching target stimulus, whereas a false alarm was defined as an incorrect "match" response to a consonant-manipulated

stimulus. When the hit rate or false-alarm rate was 0 or 1, a log-linear correction was applied. The d' value was calculated by subtracting the z score of the corrected false-alarm rate from the z score of the corrected hit rate. Differences in performance based on error type were analyzed using d' as the dependent variable, while percentage correct was reported descriptively. If a significant main effect of group was found in the mixed-design ANOVAs, Bonferroni-adjusted post hoc comparisons were conducted. The level of statistical significance was set at .05 for all analyses.

RESULTS

Phonological Representation Judgment Performance by Matching Group

Phonological Representation Judgment Performance in the Chronological Age-Matched Group

To examine differences in phonological representation judgment performance across subtypes within the CA-matched group, separate one-way ANOVAs were conducted for total task scores, as well as scores in the consonant- and vowel-manipulation conditions.

In the CA-matched group, a significant group difference was observed in total phonological representation judgment task scores ($F_{(3,78)} = 3.598, p < .05$). Tukey's post hoc test revealed that the typically developing group

performed significantly better than the phonological disorder group ($p < .01$). No other between-group differences were noted between the groups.

When analyzing phonological representation judgment performance separately for the consonant- and vowel-manipulation conditions, there was a significant group difference observed in the consonant-manipulation condition ($F_{(3,78)} = 3.264, p < .05$). Again, Tukey's post hoc test showed that the typically developing group outperformed the phonological disorder group ($p < .05$). However, no significant differences were found in the vowel-manipulation condition ($F_{(3,78)} = 1.374, p > .05$). Detailed results are presented in Table 4.

A two-way mixed-design ANOVA was conducted to investigate differences in performance between the consonant- and vowel-manipulation conditions, as well as to determine whether these differences varied across different groups. The results revealed a significant main effect of manipulation condition, showing that performance in the vowel-manipulation condition was markedly better than in the consonant-manipulation condition regardless of group ($F_{(1,78)} = 39.761, p < .001$). However, the interaction between manipulation condition and group was not significant ($F_{(3,78)} = 1.826, p > .05$).

Phonological Representation Judgment Performance in the Language Age-Matched Group

To examine differences in phonological representation

Table 4. Phonological Representation Judgment Task Performance by Subtype in the CA-Matched Group

Group	Total	Consonant Manipulation	Vowel Manipulation
Typically Developing Children	20.93(3.26)	6.36(1.77)	7.17(1.30)
Articulation Disorder	20.00(2.09)	5.67(0.81)	7.00(1.26)
Phonological Delay	20.14(3.80)	5.57(2.07)	7.14(1.46)
Phonological Disorder	17.36(3.77)	4.64(1.74)	6.27(1.61)
<i>F</i>	3.598	3.264	1.374
<i>P</i>	.017*	.026*	.259

Values are presented as mean (SD).
* $p < .05$, ** $p < .01$, *** $p < .001$.

judgment performance among subtypes in the LA-matched group, separate one-way ANOVAs were conducted for total task scores, as well as scores in the consonant- and vowel-manipulation conditions.

In the LA-matched group, no significant differences were observed in total phonological representation judgment task scores ($F_{(3,73)} = 1.871, p > .05$). This indicates that when groups were matched based on language age, total phonological representation judgment task scores did not differ significantly among the typically developing, articulation disorder, phonological delay, and phonological disorder groups.

When analyzing phonological representation judgment performance separately for the consonant- and vowel-manipulation conditions, the assumption of homogeneity of variance was violated for the consonant-manipulation condition; therefore, Welch's ANOVA was applied. The analysis revealed no significant group difference in the consonant-manipulation condition ($F_{(3,13.10)} = 1.517, p > .05$). Similarly, no significant group differences were found in the vowel-manipulation condition ($F_{(3,73)} = 0.360, p > .05$). Detailed results are presented in Table 5.

A two-way mixed-design ANOVA was conducted to

examine differences in performance between the consonant- and vowel-manipulation conditions and to assess whether these differences varied across groups. A significant main effect of manipulation condition was observed, indicating that performance in the vowel-manipulation condition was significantly higher than in the consonant-manipulation condition, regardless of group ($F_{(1,73)} = 36.309, p < .001$). In contrast, the interaction between manipulation condition and group was not significant ($F_{(3,73)} = 1.615, p > .05$).

Performance by Error Type in the Consonant-Manipulation Condition

Performance by Error Type in the CA-Matched Group

To examine phonological representation judgment performance based on error type in the consonant-manipulation condition, we calculated the percentage of correct responses and d' values for both developmental and non-developmental error types. Subsequently, a two-way mixed-design ANOVA was performed using the d' values to assess the effects of group and error type. In the

Table 5. Phonological Representation Judgment Task Performance by Subtype in the LA-Matched Group

Group	Total	Consonant Manipulation	Vowel Manipulation
Typically Developing Children	21.00(3.10)	6.33(1.82)	7.20(1.18)
Articulation Disorder	20.11(1.69)	5.78(0.83)	7.00(1.12)
Phonological Delay	18.71(4.15)	4.86(3.08)	6.71(1.38)
Phonological Disorder	18.83(3.37)	5.17(1.60)	7.00(2.00)
<i>F</i>	1.871	1.517	0.360
<i>P</i>	.142	.257	.782

Values are presented as mean (SD).

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

Table 6. Performance on Consonant-Manipulated Stimuli by Error Type in the CA-Matched Group

Group	Developmental Error Types		Non-developmental Error Types	
	Percentage Correct (%)	d'	Percentage Correct (%)	d'
Typically Developing Children	96.55(15.84)	1.77(0.41)	73.85(26.69)	1.81(1.00)
Articulation Disorder	83.33(25.82)	1.61(0.50)	66.67(14.91)	1.49(0.78)
Phonological Delay	71.43(26.73)	1.24(0.73)	69.05(27.94)	1.66(0.85)
Phonological Disorder	77.27(26.11)	1.23(0.63)	51.52(26.30)	0.85(1.08)

CA-matched group, we observed a significant main effect of group ($F_{(3,78)} = 4.904, p < .01$). However, the main effect of error type was not significant ($F_{(1,78)} = 0.005, p > .05$), nor was the interaction between group and error type ($F_{(3,78)} = 1.130, p > .05$). Bonferroni post hoc comparisons indicated that the typically developing group demonstrated significantly greater sensitivity than the phonological disorder group ($p < .01$). Detailed results are presented in Tables 6 and 7.

Table 7. Mixed-Design ANOVA Results for d' by Error Type in the CA-Matched Group

Effect	F	P
Group	4.904	.004**
Error Type	0.005	.944
Group $\times$ Error Type	1.130	.342

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

Performance by Error Type in the LA-Matched Group

To analyze the performance of phonological representation judgments based on error type within the consonant-manipulation condition, we calculated percentage correct and d' separately for developmental and non-developmental error types. We then conducted a two-way mixed-design ANOVA with d' as the dependent variable

to assess the effects of group and error type. In the LA-matched group, we observed a significant main effect of group ($F_{(3,73)} = 3.103, p < .05$). However, Bonferroni post hoc comparisons did not reveal any significant pairwise differences between groups. Additionally, there was no significant main effect of error type ($F_{(1,73)} = 0.001, p > .05$), nor was there a significant interaction between group and error type ($F_{(3,73)} = 1.566, p > .05$). Detailed results are presented in Tables 8 and 9.

DISCUSSION AND CONCLUSION

This study examined phonological representation judgment performance in typically developing children and children with articulation disorder, phonological delay, and phonological disorder across the CA- and LA-matched groups. Specifically, performance patterns were examined across the consonant- and vowel-manipulation conditions and by error type in consonant-manipulated stimuli.

First, in the CA-matched group, typically developing children showed significantly higher overall performance on phonological representation judgments than children with phonological disorder. In contrast, children with articulation disorder and phonological delay did not differ

Table 8. Performance on Consonant-Manipulated Stimuli by Error Type in the LA-Matched Group

Group	Developmental Error Types		Non-developmental Error Types	
	Percentage Correct (%)	d'	Percentage Correct (%)	d'
Typically Developing Children	95.45(17.41)	1.78(0.45)	73.64(26.78)	1.82(0.93)
Articulation Disorder	88.89(22.05)	1.72(0.43)	66.67(14.43)	1.49(0.73)
Phonological Delay	64.29(37.80)	0.97(0.79)	59.52(39.51)	1.38(1.02)
Phonological Disorder	91.67(20.41)	1.61(0.50)	55.56(22.77)	1.05(1.16)

Table 9. Mixed-Design ANOVA Results for d' by Error Type in the LA-Matched Group

Effect	F	P
Group	3.103	.032*
Error Type	0.001	.977
Group $\times$ Error Type	1.566	.205

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

significantly from either typically developing children or children with phonological disorder. In the LA-matched group, no significant differences in performance were found among typically developing children and children with articulation disorder, phonological delay, or phonological disorder. These findings suggest that performance on phonological representation judgments across subtypes of articulation and phonological disorders should be interpreted in light of both chronological age and language age. In the CA-matched group, there were no significant differences in chronological age among the groups. However, the language ages were as follows: typically developing children had a language age of 74.68 months; children with articulation disorders had a language age of 74.00 months; children with phonological delays had a language age of 66.80 months; and children with phonological disorders had a language age of 51.45 months. This means that children with phonological disorders exhibited a language age that was approximately 23 months lower than that of their typically developing peers. Phonological representations become more differentiated and refined as vocabulary develops, suggesting that they may be more closely related to language age than to chronological age. Therefore, the level of refinement in phonological representations could be more closely associated with language ability rather than simply the passage of time. In this study, the lower receptive vocabulary performance observed in children with phonological disorder may also have affected their task performance [10-12,14,24]. However, because receptive vocabulary represents only one aspect of language ability, caution is warranted when generalizing these findings to overall language development. In contrast, the similar performance observed between typically developing children and those with articulation disorders or phonological delays in the age-matched group, along with the lack of performance differences in the language age-matched group, does not necessarily indicate that the underlying factors contributing to speech sound errors are identical. The phono-

logical representation judgment task involves several steps: processing speech sound information, accessing phonological knowledge, making comparisons and judgments, and selecting responses. Similar performance on this task indicates that no significant differences were found in the judgment skills required; it does not imply that all processing characteristics associated with actual speech-sound production errors are the same. Articulation disorder, phonological delay, and phonological disorders can be distinguished based on the specific patterns of speech sound errors they produce. In particular, phonological delays and phonological disorders may differ in the developmental status of their error patterns and in the organizational characteristics of the phonological system [1,21,22]. Therefore, the lack of performance differences among certain subtypes in this study does not necessarily indicate that their underlying processing characteristics are identical. Rather, any such differences may not have been clearly captured by the judgment processes required in this task. In other words, when language age is matched, performance in phonological representation judgment may seem similar across groups. However, this does not imply that the characteristics of errors observed in actual speech sound production are the same. Thus, when interpreting phonological representation judgment performance among different subtypes of articulation and phonological disorders, it is essential to consider not only the language age but also the nature of actual speech sound production errors and the processing demands imposed by the task.

Second, in both the CA- and LA-matched groups, performance on vowel-manipulated stimuli was significantly higher than performance on consonant-manipulated stimuli. In addition, the interaction between group and manipulation condition was not significant, suggesting that the higher performance on vowel-manipulated stimuli may reflect a pattern common across subtypes of articulation and phonological disorders rather than a subtype-specific characteristic.

When examining performance by manipulation condition, typically developing children in the CA-matched group performed significantly better on consonant-manipulated stimuli compared to children with phonological disorders. In contrast, children with articulation disorders and phonological delays did not show significant differences in performance compared to either typically developing children or children with phonological disorders. In the LA-matched group, no significant differences in performance were found among typically developing children and those with articulation disorders, phonological delays, or phonological disorders. In the vowel-manipulation condition, there were also no significant differences among typically developing children and those with articulation disorders, phonological delays, or phonological disorders in either the CA- or LA-matched groups. This suggests that the observed difference in overall task scores between typically developing children and children with phonological disorders in the CA-matched group may be more closely linked to performance on consonant-manipulated stimuli rather than on performance on vowel-manipulated stimuli.

The relatively higher performance on vowel-manipulated stimuli may be due to differences in the acoustic cues provided by vowels and consonants. Vowels typically provide greater acoustic energy and sustained formant information, while consonants rely on the ability to discriminate brief transitional cues associated with place and manner of articulation and phonation type [27,28]. Therefore, the vowel-manipulated stimuli used in this task likely provided more salient cues for perceiving and judging differences from the target word.

Additionally, performance was analyzed by classifying consonant-manipulated stimuli according to developmental and non-developmental error types. Regarding the percentage of correct responses, developmental error types generally resulted in higher accuracy than non-developmental error types in both the CA- and LA-matched groups. However, analyses based on d' values revealed no

significant differences in discrimination sensitivity by error type in either the CA- or LA-matched groups. Furthermore, there was no significant interaction between group and error type, indicating that performance patterns by error type did not differ across the various subtypes of articulation and phonological disorders.

The differing patterns observed between percentage correct and d' values may reflect the different information these two measures capture. The percentage correct indicates the proportion of accurate responses to stimuli representing developmental and non-developmental error types, whereas d' reflects sensitivity for discriminating target words from manipulated stimuli by considering both hits and false alarms. Therefore, although the percentage correct was higher for developmental error types, the lack of a significant difference in the d' analysis prevents the conclusion that developmental error types were inherently easier to judge than non-developmental error types.

Therefore, findings related to error type should be interpreted as exploratory. In the present study, the number of items representing developmental and non-developmental error types was unequal, and the same target words were not manipulated to create both error types. Accordingly, it is difficult to disentangle whether judgment differences by error type were attributable to error type itself or to characteristics inherent in the target words. Nevertheless, these findings highlight the need for a more precise examination of whether judgment patterns for stimuli representing developmental and non-developmental error types differ across subtypes. Future studies should construct balanced developmental and non-developmental error-type stimuli for the same target words and control the number of items to examine the relationship between subtype and error type.

This study also had several limitations, including the relatively small and unequal sample sizes across groups and the fact that the chronological-age-matched and language-age-matched groups did not have identical sample

compositions. Therefore, the performance patterns observed in the two matched groups may reflect not only differences in the matching criteria but also, in part, differences in sample composition. In addition, the language-age-matched group was constructed based on receptive vocabulary, and target-word familiarity and phonological complexity were not controlled using objective measures. Therefore, caution is warranted when interpreting and generalizing the findings.

The significance of this study lies in its examination of phonological representation judgment performance across different subtypes of articulation and phonological disorders. This analysis goes beyond simply comparing mean differences between groups; rather, performance was examined under separate chronological-age-matched and language-age-matched conditions. This approach suggests that phonological representation judgment performance may vary depending on the relationship between disorder subtype and level of language development, rather than represent a fixed trait of these subtypes. Additionally, by categorizing consonant-manipulated stimuli into developmental and non-developmental error types and examining discrimination sensitivity, this study expands the analysis of phonological representation judgment tasks beyond total scores and conditions involving consonant and vowel manipulation. These findings emphasize the need for further research into the relationships between developmental and non-developmental error types and the various subtypes of articulation and phonological disorders. Future studies should aim to recruit sufficiently large and balanced participant groups across the subtypes of articulation and phonological disorders. Moreover, they should build upon the current findings by employing study designs that account for both chronological age and language age.

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