4-3-2024

Different Error Patterns of /l/ in Children and Speech-Language Pathologists' Perception and Treatment

Grace E. Lemoine
Louisiana State University and Agricultural and Mechanical College

DIFFERENT ERROR PATTERNS OF /l/ IN CHILDREN AND SPEECH-LANGUAGE PATHOLOGISTS' PERCEPTION AND TREATMENT

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Communication Sciences and Disorders

by
Grace Elizabeth Lemoine
B.A., Louisiana State University, 2022
May 2024

Acknowledgements

I would first like to thank my thesis advisor, Dr. Hyunju Chung, for her help, guidance, dedication, and support. I have learned so much from her knowledge and expertise, and I am so grateful for her patience, understanding, and encouragement during this process. Dr. Chung provided guidance when I needed it while also allowing me to develop my own ideas and be independent in my work. Thank you, Dr. Chung, for all the experiences and opportunities to learn from you and for helping me grow as a student, researcher, and clinician.

I would also like to thank Dr. Janna Oetting and Dr. Eileen Haebig for serving on my thesis committee and for giving their feedback, guidance, and support during this process. I was honored to learn from them and to have their input and expertise to help better my thesis project. Thank you, Dr. Haebig and Dr. Oetting, for helping to make this thesis process a positive and constructive experience.

Additionally, I would like to thank everyone who participated in my study and helped with the recruitment process. This would not have been possible without you!

Finally, I would like to thank my family and friends for their love, support, encouragement, and understanding. Thank you for listening to me, believing in me, and encouraging me when I needed it most. I am extremely grateful for all of you, and without you, I would not be the person I am today!

Table of Contents

Illustrations

Tables

Figures

Abstract

Children often simplify target speech sounds using phonological processes, or common developmental error patterns. However, some children produce less common error patterns that differ from common errors. In the current study, less common errors involving /l/ sounds were studied as the phoneme /l/ is a sound that is subject to frequent misarticulations in young children and perceptual confusion among listeners. The current study focused on less common errors because studies have suggested that atypical errors can indicate weak phonological representations and poor phonological awareness skills, which can have long-term effects on children's literacy skills. Therefore, the aim of the current study was to better understand types of less common errors of /l/ in children and examine speech-language pathologists' (SLPs') perception and treatment of these errors. Participants included 22 certified speech-language pathologists with experience in assessing and treating children's speech. Listeners judged the perceptual acceptability of children's correct productions, common error productions, and less common error productions of word-initial /l/ using a multiple-choice task and visual analog scale. Listeners also selected how they would treat less common /l/ errors in the clinical setting. Results showed that there was variability in listeners' perception of less common errors of /l/ as compared to correct and common error productions and that SLPs used many different treatment methods for these errors. This demonstrates a need for more consistent terminology, comprehensive literature, and perceptual training regarding less common speech errors involving /l/.

Chapter 1. Introduction

Phonological processes refer to patterns of sound errors used by young children to simplify a target speech sound. Phonological processes are natural processes of speech production, and most phonological processes are suppressed, or no longer used, by 3-7 years of age in children with typically developing speech (TDS) when the child learns to accurately produce the sound (American Speech-Language-Hearing Association, 2015; Donegan & Stampe, 1979; Peña-Brooks & Hedge, 2007).

However, there are some children who use these phonological processes past the age at which they should be suppressed. These children are classified as having a phonological delay or *delayed speech development*, which refers to the presence of speech error patterns that are typically produced by at least 10% of children of a younger chronological age (Dodd, 2011). There are also children who show error patterns that are not commonly shown in children with TDS, which cannot be explained by typical phonological processes. These children are classified as having *disordered speech*, which refers to the presence of at least one error pattern that is atypical of any age (Dodd, 2011).

Although there have been extensive studies on typical error patterns, there has been less attention on atypical error patterns of speech. It is important to investigate these atypical patterns closely because studies have suggested that atypical errors indicate weak phonological representations in a child and poor phonological awareness (PA) skills, which can have long-term effects on children's literacy skills (Anthony et al., 2010; Brosseau-Lapre & Roepke, 2019; Dodd, 2013; Leitão & Fletcher, 2004; Preston & Edwards, 2010). Additionally, studies have shown that children who produce atypical errors are also less likely to standardize their speech without the help of intervention (Broomfield & Dodd, 2005; Hua, 2002; Leonard, 1973).

Likewise, although the implications of atypical error patterns have been suggested, not many studies have investigated specific types of less common error patterns or treatment approaches for these errors. Therefore, the aim of the current study is to better understand types of less common errors and speech-language pathologists' perception and treatment of these errors focusing on one sound that is subject to frequent errors in young children, the lateral liquid /l/.

Chapter 2. Literature Review

Speech Sound Development and Error Patterns in Children's Speech

Children develop spoken language in an orderly progression by listening to the languages around them. Speech-production skills occur in a sequence of stages with each stage building on the previous stages in a systematic way (Stark, 1980). Typically, children learn to develop vowel sounds by the age of 3;0 and most consonants by the age of 5;0 (McLeod & Crowe, 2018; Smit et al., 1990; Templin, 1957). Specifically, /p, b, m, d, n, h, t, k, g, w, ŋ, f, j/ are classified as "early" sounds and are developed by the ages of 2;0 – 3;11, and /l, ʤ, ʧ, s, v, ʃ, z/ are classified as "middle" sounds and are developed by the ages of 4;0 – 4;11 (McLeod & Crowe, 2018). "Late" sounds include /ɹ, ʒ, ð, θ/ and are known to develop between the ages of 5;0 – 6;11 (McLeod & Crowe, 2018).

Children's phonological representations are also believed to become more refined as they develop their understanding of the sounds and sound patterns within their language (Preston et al., 2013). As children learn to produce adult-like speech sounds, children with TDS and those with speech sound disorders (SSD) simplify adults' speech patterns by using different phonological processes. Phonological processes can be characterized into three categories: *assimilation*, where one sound becomes similar to a nearby sound (e.g., "*gog*" for *dog, "nandy"* for *candy*); *substitution*, where one sound is systematically substituted for another sound (e.g., "*tar"* for *car, "wabbit"* for *rabbit*); and *syllable structure*, where sound changes impact the syllabic structure of a word (e.g., "*top"* for *stop*, "*nana"* for *banana*) (American Speech-Language-Hearing Association, 2015). These typical simplifications of sounds are not of concern if produced at the appropriate age; most children are able to develop intelligible speech on their

own by the age of 4;0 by listening to the sounds around them and without the need for explicit teaching (Coplan & Gleason, 1988; Van Riper, 1939).

Atypical Error Patterns

While children usually show the above listed common error patterns, some children also show patterns that we normally do not see in children with TDS. Atypical error patterns, which are also referred to as *nondevelopmental errors* or *rare error types*, are errors that are less commonly produced by children of any age and have been described as unusual or deviant (e.g., Brosseau-Lapre & Roepke, 2019; Dodd, 2005; Dodd & Iacano, 1989; Dodd et al., 1989; Edwards & Shriberg, 1983; Ingram, 1976; Klein & Spector, 1985; Leonard, 1985; Lowe, 1994; Preston & Edwards, 2010; Smit et al., 1990). Atypical error types include deleting initial consonants in words (word-initial consonant deletion) (e.g., "*at"* for *cat*) or replacing a front sound with a back sound (backing) (e.g., *"he"* or *"gee"* for *see*) (Dodd & Iacano, 1989; Preston & Edwards, 2010). Another example of atypical error types is glottal stop substitution, when a consonant is substituted with a glottal stop, or a sound produced in the back of the throat (e.g., *"fu-ie"* for *funny*) (DeWitt, 2019).

Implications of Atypical Errors

The production of atypical error patterns has several implications regarding children's development. Although other studies have reported low occurrences of persistent atypical speech sound errors (e.g., Preston et al., 2013; To et al., 2022), some studies have shown that children with atypical speech errors are at a greater risk of not developing typical speech without clinical intervention (Leonard, 1973). For example, a small study by Hua (2002) assessed young children in Beijing with no available speech-language pathologist services. An initial assessment revealed two children who consistently produced atypical errors and three children who were using

delayed phonological error patterns. When assessed nine months later, the children who produced atypical errors were still exhibiting disordered speech, while one of the phonologically delayed children was producing age-appropriate errors. Another study by Broomfield and Dodd (2005) examined children in the United Kingdom who were on a six-month waitlist for speech therapy. The results showed that children with disordered speech (who consistently produced atypical errors) did not make progress, while the phonologically delayed children (who produced errors accounted for by phonological processes at a younger age level) did make progress.

Additionally, atypical errors have implications regarding a child's phonological system. Studies have shown that atypical error patterns are reported to indicate poor phonological representations of a child, or poor mental representations of sounds and sound combinations of a language (Anthony et al., 2010; Brosseau-Lapre & Roepke, 2019; Dodd, 2013). Studies such as Preston and Edwards (2010) and Leitão and Fletcher (2004) have shown that children who produce atypical errors score significantly lower on school-age PA measures, or measures that relate to the ability to recognize and manipulate sounds in spoken words and sentences. These findings are congruous with the idea that weak phonological representations may be the basis of both atypical error patterns and poor PA skills (Preston & Edwards, 2010; Preston et al., 2013).

This is especially important because poor PA skills can have long-term effects on children's literacy skills and academic success, especially if their speech deficits persist after entering school or when a language impairment is present (e.g., Nathan et al., 2004; Raitano et al., 2004; Snowling et al., 2000). Leitão and Fletcher (2004) showed that speech disorders characterized by atypical errors and associated with poor phonological representations place the child at risk for future difficulties with acquiring literacy. The study followed children who originally produced non-developmental errors and had difficulty with PA tasks at 5-6 years of

age and low average reading skills and poor spelling skills when they were 7 years old (Leitão et al., 2000; Leitão et al., 1997; Leitão et al., 1998). Children from these original studies were followed up and reassessed at age 12-13 and exhibited continuing difficulties with reading accuracy, phonemic decoding, and spelling (skills that rely on intact phonological representations and phonological processing). They also reported weaknesses in reading comprehension, further providing evidence for persistent difficulties in students who begin school with a speech disorder consisting of atypical speech errors. Therefore, it is important for SLPs to identify children who produce atypical errors and utilize treatment methods that target their poor phonological representations and PA skills that can impact a child's literacy skills.

Lastly, children with speech disorder who produce atypical error patterns have also been reported to perform less well than phonologically delayed children on cognitive-linguistic tasks, exhibiting weaknesses in cognitive flexibility and abstracting nonlinguistic rules (Dodd, 2011). Flexible cognition, or the part of intelligence that permits children to incorporate new information during learning, is needed for phonological development because children must alter their phonological representations and responses depending on input from the environment (De´ak, 2003; Dodd, 2011). Difficulty with abstracting and implementing rules of the phonological system aligns with findings regarding the traits of disordered speech and children's lack of spontaneous change without intervention (Dodd, 2011; Dodd et al., 2000). Research supports intervention that targets speech-processing deficits that underlie a child's disordered speech in order to efficiently create necessary systemwide change that otherwise may not occur without intervention (Stackhouse & Wells, 1997).

All these findings suggest the significance of early identification and treatment in children who produce atypical error patterns and of providing appropriate intervention for

children who produce these atypical errors. To better understand less common errors produced by young children and how these sounds are perceived in clinic, the current study examined different error patterns and SLPs' perception of these productions involving one of the English sounds, lateral liquid /l/, as a target sound.

English Lateral Liquid /l/: Characteristics, Development, and Error Patterns in Young Children

Characteristics of /l/

English lateral liquid /l/ is an articulatory challenging sound due to a complex gesture that involves both an anterior and posterior lingual constriction. These lingual constrictions are characterized by tongue tip raising and tongue dorsum retraction (Browman & Goldstein, 1989; Gick, 1999; Sproat & Fujimara, 1993). In the anterior constriction, the tip of the tongue makes contact with the alveolar ridge for tongue tip closure. In the posterior constriction, the tongue dorsum, or body of the tongue, retracts toward the back of the throat, and the tongue dips laterally (Narayanan et al., 1997). In American English, production of /l/ can vary by word position and by dialect. Typically, word-initial /l/ is associated with the anterior constriction occurring earlier than the posterior constriction, while word-final /l/ is associated with the posterior constriction occurring earlier than the anterior constriction (Sproat & Fujimara, 1993). However, in some dialects, speakers may produce /l/ with an earlier posterior constriction (typically associated with word-final /l/ or "dark /l/"), regardless of word position. Therefore, production of /l/ not only involves a complex articulatory gesture, but there is also variation in the production of /l/ based on word position and dialect.

In addition to being an articulatorily challenging sound, /l/ is also subject to perceptual confusion. This is due to the acoustic proximity of /l/ with other semivowel sounds, specifically /w/. Semivowel sounds (/w/, /j/, /ɹ/, /l/) share an articulatory characteristic with each other in that

all of these four sounds involve movement to and away from a constriction in the vocal tract that is tighter than that for vowels, but not as tight as other consonant sounds (Hixon et al., 2018). Thus, these sounds share some prominent acoustic features; all semivowel sounds have an interval where F1, F2, and F3 are relatively constant, and all have large transitions in at least one of the first three formants going in and out of the steady formant frequencies (Hixon et al., 2018). The first formant frequency, or F1, is similar across all semivowels. Child and adult speakers distinguish /l/ from /ɹ/ along F3, while adults distinguish /l/ from /ɹ/ with a lower F2 (Howson & Redford, 2021). Most acoustically similar of the semivowels are /l/ and /w/, which both have a wide frequency separation between F2 and F3 and are distinguished from each other by the second formant (Dalston, 1975; Hixon et al., 2018). Because /l/ most closely shares similar acoustic characteristics with /w/, this makes it difficult to perceptually differentiate between /w/ and /l/ and causes frequent misperception of the /l/ sound.

Development and Error Patterns of /l/

The phoneme lateral liquid /l/ is associated with higher misarticulation rates among children with TDS or SSD (Chung, 2020; Hodson & Paden, 1981; Lin & Demuth, 2015; Smit et al., 1990). Traditionally, English lateral liquid /l/ is considered to develop later in the phonological system of a child. Shriberg (1993) classified /l/ as one of the "late 8" sounds, meaning that it is one of eight consonants (/ʃ, θ, s, z, ð, l, r, ʒ/) that develop between five and seven years of age. Recently, in their review study, McLeod and Crowe (2018) classified /l/ as one of the "middle" sounds that develops between the ages of 4;0 – 4;11. Some other studies that examined the acquisition patterns of /l/ by word position showed that word-initial /l/ can be acquired by 2;0 or 3;0 (e.g., Chung, 2020; Dyson, 1988; Lin & Demuth, 2015), while word-final /l/ is acquired after 7;11 (Lin & Demuth, 2015).

When misarticulated, /l/ is often substituted with other sounds or is deleted, both in singleton and in clusters. For /l/ clusters (e.g., *blue*, *play*, *splat*), cluster reduction/simplification, where a consonant cluster of two or more consonants is lessened into a single consonant through omission (e.g., "back" for *black*, "spat" for *splat*), or substitutions to other sounds (e.g., "cwoud" for *cloud*) are the most common error patterns. For singleton /l/, types of errors differ by word position. For word-initial /l/, one of the most common error patterns includes *liquid gliding*, which refers to an error pattern where a child substitutes a liquid sound (/l, r/) with a glide sound (/j, w/) (Hodson & Paden, 1981). An example of liquid gliding is when a child says [jaɪk] for *like* or [wɛd] for *red*. For word-final /l/, one most typical error pattern involves vocalization, where /l/ is produced as either a back vowel or a glide (Hardcastle & Barry, 1989). Examples include [tɔ] or [tɔə] for *tall* and [siə] for *seal*. Chung (2020) found that the most common error pattern for word-final /l/ in Southern White Vernacular English (SWVE)-speaking children was vocalization, with a percentage of occurrence of 95% of instances.

Less Common Error Patterns of /l/

Other types of error patterns involving /l/ aside from gliding and vocalization have been scarce in the literature. However, there have been some examples that discuss error patterns of word-initial /l/ that differ from common gliding errors. For example, instances of children who produce nasalization of /l/ have been described by SLPs online, and these SLPs have asked for clinical opinions regarding how to effectively treat this less common error (Marshalla, 2011, 2012). Another error pattern of /l/ that differs from gliding is /d/ substitution, where children produce [d]-like productions for /l/ (Gick et al., 2007). However, there has not been any systematic analysis regarding these less common error patterns of /l/. One factor that may contribute to the lack of data on other types of /l/ error patterns could be the nature of children's

productions of the /l/ sound, which vary articulatorily and acoustically between /l/ and other error sounds, making it difficult to classify the sound into one phonemic category.

Perception and Treatment of Children's Speech Sounds

As previously described, the phoneme /l/ shares articulatory properties with the other semivowel sounds (/w/, /j/, /ɹ/), resulting in semivowel sounds sharing many acoustic features among each other. This makes semivowel sounds perceptually challenging, specifically differentiating /l/ from /w/ (O'Connor et al., 1957). Additionally, some children produce "intermediate" productions with acoustic-articulatory characteristics that are between the target sound and error sound, making it difficult for listeners to categorize the sound into an acceptable phonemic category (e.g., Baum & Mcnutt, 1990; Macken & Barton, 1980; McAllister Byun et al., 2016; Meyer & Munson, 2021). This makes it difficult to judge children's speech sounds perceptually and can cause difficulty with assessment and intervention (Bernstein, 2015). Due to these difficulties, /l/ may be categorized as certain sounds (e.g., /w/ or /j/) more often than other less common error sounds.

Also, listeners' speech perception varies by many factors, such as the speaker or listener's age, gender, dialect, emotional state, or identity (Holt & Lotto, 2010). Specifically, when asked to judge speech sounds produced by children, studies have shown that listeners demonstrate a perceptual bias regarding children's productions. For instance, a study by Munson et al. (2010) analyzed listeners' perception of sound productions of 2- to 5-year-old children embedded in different carrier phrases; some were placed in phrases without any speech errors, while others were placed in phrases with speech sound errors. The results showed that listeners tended to rate productions as accurate when they believed the child speaker to be older (i.e., when the sound was placed in a phrase with no errors) compared to when bias caused them to believe the speaker

was younger (i.e., when the sound was placed in a phrase with speech errors). Similarly, in another study, Chung et al. (2023) examined listeners' perception of child and adult word-final /l/ productions embedded in monosyllabic words. The results showed that listeners were more likely to judge word-final /l/ as correct when produced by adult speakers, while they were more likely to perceive word-final /l/ as incorrect when produced by a child, regardless of the acoustic similarities between adult and child word-final /l/ productions. This demonstrates that listeners show implicit bias based on the perceived age of the speaker.

In addition to the factors discussed above, listeners' perception of children's speech sounds can also vary by their experience with child speech. For example, Klein et al. (2012) studied experienced (i.e., SLPs) and inexperienced (i.e., graduate students) listeners' perception of one of the semivowel sounds, /r/, and found that inexperienced listeners had greater variation in their judgments of intermediate productions of /r/. This suggests that more perceptual training on children's speech sounds could be helpful in increasing consistency of perceptual judgements of intermediate productions and might also be beneficial for being less biased by external factors.

Treatment of Atypical Error Patterns

Currently, there is limited information on how atypical errors are being treated in the clinical setting. Some existing studies that report treatment methods of atypical errors have suggested that these errors may improve using traditional phonological approaches, such as minimal pairs approach (Dodd & Iacano, 1989; Leonard & Brown, 1984; Preston & Edwards, 2010). However, online SLP testimonies have described the use of other approaches for less common error patterns of /l/ (specifically nasalization) in the clinical setting, such as using therapy tools to demonstrate oral versus nasal resonance, shaping vowel sounds into consonant sounds, and using tactile cues to facilitate accurate resonance (Marshalla, 2011, 2012). This

reflects a lack of consistency in SLPs' use of treatment methods, which range from traditional phonological methods to other articulation methods that are specific to the articulatory or resonant nature of the error. This indicates the need for more studies on less common error patterns and further examination of the methods that SLPs are using to treat less common error patterns of /l in the clinical setting.

Therefore, the purpose of the current study is to a) understand types and SLPs' perception of less common error patterns involving /l/ and b) examine treatment methods SLPs use to treat these errors. The specific research questions are as follows:

a. What are the types of less common errors of /l/, and do experienced SLPs show consistency in accuracy judgment of these errors?
b. What treatment methods do SLPs use for less common error patterns of /l/, and are they similar to or different from methods used to treat common error patterns?

In response to the first research question, it was hypothesized that there would be variability in SLPs' perception of less common error patterns of /l/ due to /l/ being a sound that is subject to perceptual confusion and because children often produce intermediate productions that are difficult to categorize perceptually. In response to the second research question, it was predicted that SLPs' treatment methods for less common /l/ errors would vary by SLPs and include a combination of different treatment methods.

Chapter 3. Methods

Participants

Listeners included 28 certified SLPs who were monolingual English speakers with experience with assessing and treating children's speech. Listeners who were not experienced with children's speech, were not monolingual English speakers, and/or had a history of hearing difficulties were not included in the study. Three listeners reported a history of speech/language difficulties (all SSD); however, all three participants reported that these difficulties were resolved and were therefore included in the study. One participant reported a history of hearing loss, one listener reported technical difficulties, one listener did not yet have their certification of clinical competence, and three listeners did not fully complete the survey; therefore, these participants were excluded from the study, resulting in a total of 22 listeners.

Each participant was asked to complete a questionnaire to document their amount and type of clinical experience, including city and states they have practiced, backgrounds of populations they have worked with, age range of children they have worked with, and the kinds of speech sound errors they have treated (see Appendix A). Listeners' amount of clinical experience ranged from 2 to 36 years, with the mean being 21;6 (years; months). Most listeners reported working with child clients very frequently and reported having experience with children ranging in age from 2 years old to high school age. The majority of listeners reported having practiced in Louisiana, but some listeners reported having practiced in other states (e.g., Mississippi, Tennessee, Texas, Florida, North Carolina, Kentucky, Illinois, Wisconsin, Minnesota, California, and Hawaii). Other details regarding listeners' background information including city/states practiced, backgrounds of populations worked with, and clinical settings worked in are summarized in Appendix B.

Table 3.1. Participant background by years of clinical experience, current exposure to children, and age range of patients worked with.

Participant ID	Years of Clinical Experience (years; months)	Current Exposure to Children	Age Range of Patients Worked With
L01	21	Very frequently	2 years old - adult
L02	23	Very frequently	2 years old – high school
L03	25	Very frequently	2 years old - Pre-k, K - 5th grade, high school
L04	30	Very frequently	2 years old - adult
L05	2;6	Very frequently	2 years old – high school
L06	24	Never	K - adults
L07	15	Never	K – 5th grade, adults
L08	38	Often	2 years old – high school
L09	31;6	Very frequently	2 years old – high school
L10	40	Often	2 years old - Pre-k, K - 5th grade, middle school, adults
L11	2	Very frequently	2 years old – 5th grade
L12	23	Very frequently	2 years old – high school
L13	19	Very frequently	K – 5th grade
L15	31	Very frequently	2 years old – 5th grade
L16	36	Often	2 years old – high school
L17	29	Very frequently	2 years old - adults
L18	29	Very frequently	2 years old - Pre-k, K - 5th grade, middle school, adults
L20	4;6	Very frequently	2 years old - adults
L23	14	Very frequently	2 years old – middle school
L24	10	Very frequently	2 years old - adults
L27	21	Very frequently	2 years old – adults
L28	5	Very frequently	K – 5th grade

On-campus and local recruitment was done through flyer distribution and word of mouth. The involvement of the study was voluntary, and no one was obligated to participate in the study. All procedures involving recruitment, data collection, and data analysis were approved by the Institutional Review Board of Louisiana State University (IRB# 1254) (see Appendix C).

Stimuli

The stimuli used in the current experiment were from a larger study on child semivowel productions (Chung, 2020; Chung & Weismer, 2021). The child speakers included children who were speakers of monolingual SWVE, aged between 2 to 6 years, and had TDS or SSD. Target words included monosyllabic words that contain /l/ in word-initial position across different vowel contexts, as summarized in Table 3.2.

Table 3.2. List of target words.

Vowel context	Target words
/i, ɪ/	leaf, lick, lip
/u, ʊ/	loop, lose, look
/ɑ, ɔ/	lock, log
/ɛ, e/	leg, late, lake
/æ/	laugh
/ʌ/	love

The author, who had taken courses in phonetics, acoustics, and SSD; received training on semivowel sounds for two years; and completed 1 year of graduate clinical practicum listened to these productions and categorized each production into one of three categories: correct, common errors (gliding), or less common errors (errors other than typical gliding errors). Another transcriber who had received similar training as the author also listened to these productions for interrater reliability, and the agreement was 90%. Productions were balanced between correct productions, common error productions, and less common error productions and then randomized. Half of the productions were repeated twice in the experiment for intra-rater reliability. The number of tokens in each category (correct, common errors, less common errors) are summarized in Table 3.3. Intensity of the tokens was normalized to 70 dB using a customized *Praat* script to control the intensity of all productions (Boersma & Weenink, 2023; Winn, 2020).

Table 3.3. Number of tokens by category.

	Number of tokens
Correct	20
Common errors	20
Less common errors	20
Total	**60**

Procedures

Testing took place remotely at the listener's convenience via an online Qualtrics survey. At the beginning of the survey, participants completed a consent form and questionnaire detailing their experience with less common error patterns of /l/ and how they have treated those errors. The perceptual task began with verbal and written instructions followed by a set of practice productions to familiarize participants with testing procedures. Then, participants were presented with recordings of target words containing children's common and less common productions of word-initial /l/. Participants were given the written target word for each recording (see Figure 3.1), so they were aware of what target word the child was producing. Participants were then asked to judge the perceptual acceptability of the production using a multiple-choice task and visual analog scale (VAS). The options provided for the multiple-choice task were Correct, Deletion, Distortion, Substitution (to _), or Other, and the VAS ranged from "I heard the /l/ sound produced incorrectly" to "I heard the /l/ sound produced correctly." For the VAS task, participants were instructed to use the entire scale when rating the sound. Examples of the multiple-choice task and VAS are shown in Figures 3.1 and 3.2, respectively.

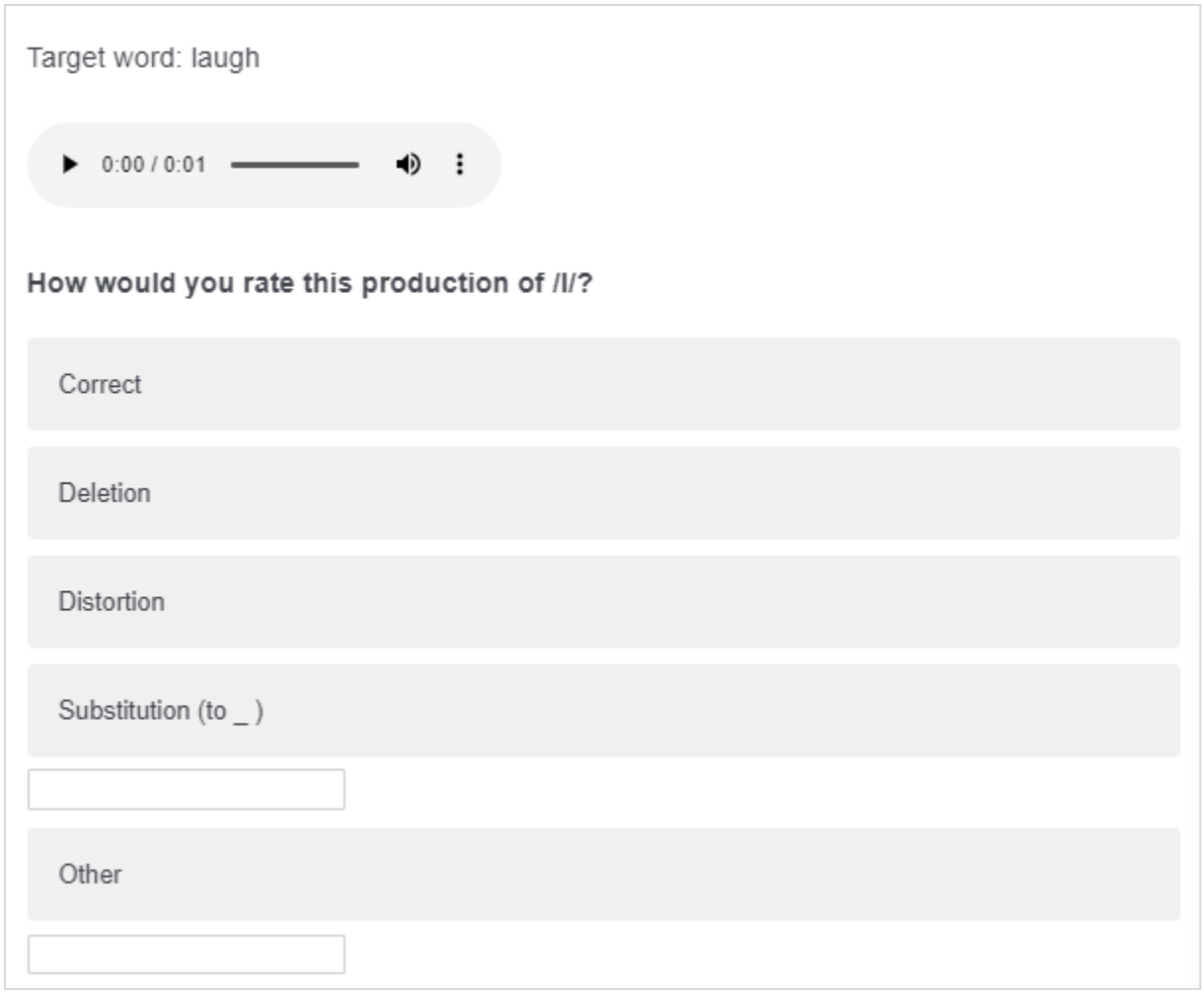

Figure 3.1. Example of multiple-choice task.

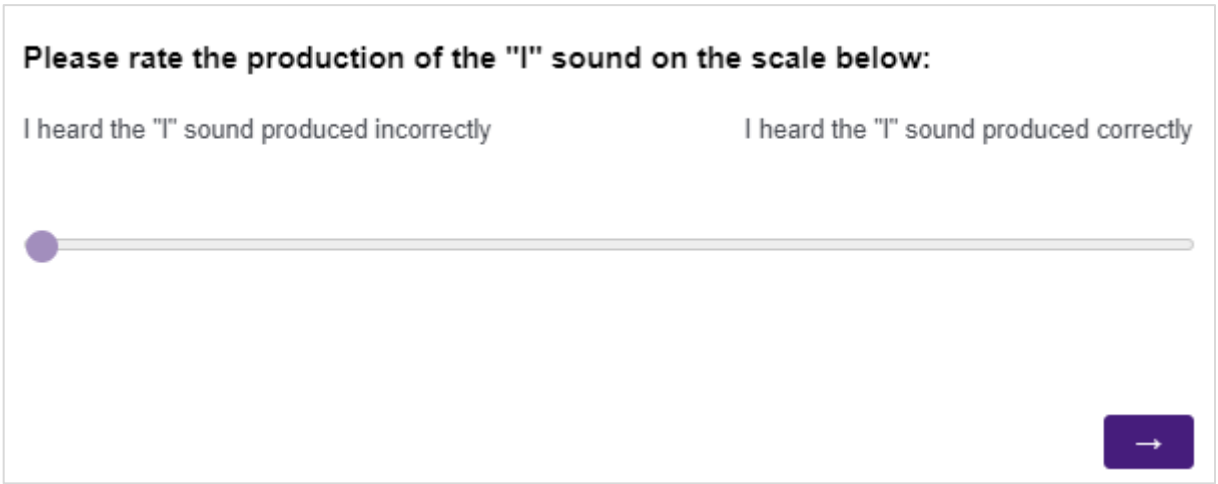

Figure 3.2. Example of VAS task.

After listeners finished the perceptual task, they were asked to judge five productions of less common errors and select which methods they would use to treat each error in the clinical setting. Multiple-choice options for the treatment task included a) Placement cues (verbal, visual, tactile), b) Discrimination tasks (e.g., minimal pairs approach), c) Facilitating contexts (opportunity to produce /l/ correctly based on surrounding phonemes), d) Therapy tools to demonstrate oral vs. nasal resonance, e) Shaping vowel sounds into consonant sounds, f) Using tactile cues to facilitate oral vs. nasal resonance, and g) Other. Listeners were able to select as many methods as they thought were appropriate. An example of the treatment task of the experiment is shown in Figure 3.3.

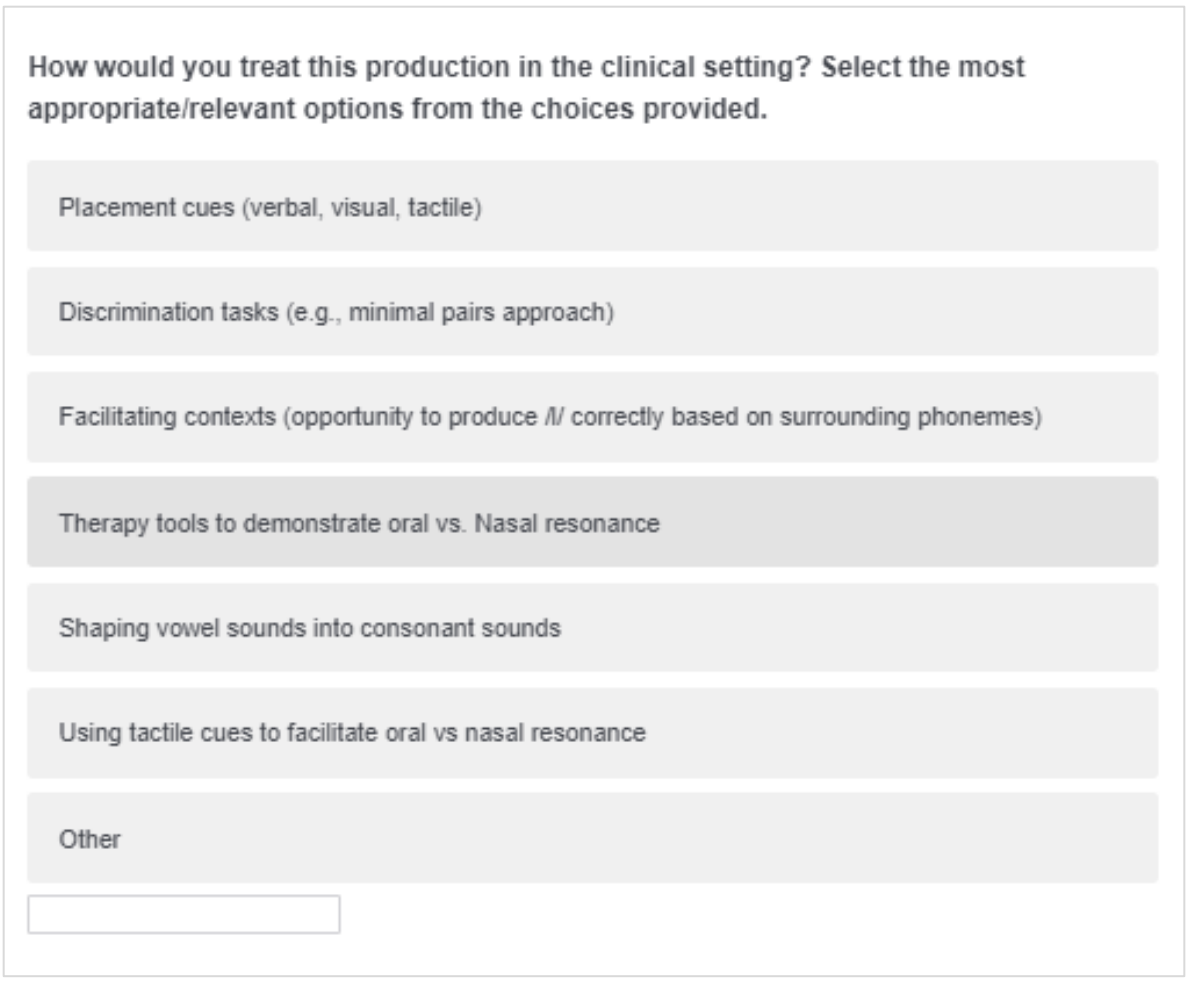

Figure 3.3. Example of treatment task.

Data Analysis

To address the first research question regarding the types of less common errors of /l/, children's productions of word-initial /l/ were further categorized by error pattern to determine the types of less common error patterns of /l/ that children produce. To address the question of whether SLPs show consistency in accuracy judgment of less common errors of /l/, results from the multiple-choice and VAS tasks were analyzed. First, for the multiple-choice task, percentage agreement with the listener categorization responses and the original categorization was calculated for each listener and for each category. Those percentage agreement scores were then averaged across listeners to obtain an average percentage agreement score for each category. If listeners chose a

multiple-choice response other than *substitution* but provided a written description that indicated their perception of some nasality in the stimuli, these responses were re-coded as examples of *nasalization*. For example, if a listener selected the multiple-choice category of *other* but provided a written description of "slightly nasalized," "nasalization," or "resonance influenced error," this was coded as *nasalization*. Likewise, if listeners chose the multiple-choice selection of *other* but provided written responses such as "omitted" or "omission of /l/," these responses were categorized into the *deletion* category. Examples of how listeners' responses were coded are shown in Table 3.4.

Table 3.4. Examples of coding based on listeners' responses.

Original Category (multiple choice options)	**Listener Responses**	**Coding**
Correct	Correct	Correct
Deletion	Deletion	Deletion
Distortion	Distortion	Distortion
Substitution (to_____)	/w/ or /j/	Gliding
	/n/	Nasalization
	/d/	/d/ substitution
Other	slightly nasalized, nasalization, resonance influenced error	Nasalization
	Omitted, omission of /l/	Deletion

For the VAS task, the mean and median of VAS ratings for all listeners was calculated for each category. The standard deviation (SD) for each category was also calculated to determine the distribution of listeners' responses. For the statistical analysis, a non-parametric equivalent of one-way ANOVA, Kruskal-Wallis test, was used to examine differences in VAS ratings across the groups (original categories). Kruskal-Wallis test was used as Shapiro-Wilk's normality test showed that the data violated the assumption of normality. All the statistical analyses were conducted using *shapiro.test()* and *kruskal.test()* functions in R software (R Core Team, 2023). The pairwise comparisons were also performed using *pairwise.wilcox.test()* function in order to determine which groups differ from each other. Interrater reliability was calculated using an i*cc()* function in R software for each rating category (R Core Team, 2023).

One listener, L03, was removed for the VAS rating analysis due to only selecting binary choices (0 or 1) and therefore exhibiting unreliable ratings.

For the second research question on the kinds of approaches SLPs use to treat less common errors of /l/, a descriptive analysis was used. Additionally, responses from the treatment task were analyzed descriptively to determine specific methods reported by SLPs to treat each less common error.

Chapter 4. Results

Types of Less Common Errors of /l/

Child productions of word-initial /l/ that were categorized by a trained transcriber as *less common errors* were examined and further classified into specific error patterns. Examination of these productions showed that less common errors consisted of three error patterns: a) nasalization, b) /d/ substitution, and c) word-initial /l/ deletion. Nasalized productions were productions that contained varying degrees of nasalized resonance, ranging from slightly nasalized to complete substitution of /n/ for /l/ (e.g., [nɑk] for *lock,* [nɪp] for *lip,* [næf] for *laugh*). Productions were categorized as */d/ substitution* when word-initial /l/ was substituted with the phoneme /d/ (e.g., [duz] for *lose*, [dup] for *loop*). Productions categorized as *word-initial /l/ deletion* included productions where word-initial /l/ was omitted (e.g., [up] for *loop,* [ɔg] for *log*).

Multiple-Choice Task

Results for the multiple-choice task showed that the *correct* and common error pattern, *gliding,* categories have the highest percentage agreement, with the percentage agreement being 94.78% and 82.95%, respectively. Regarding percentage agreement for the less common error patterns *(nasalization, /d/ substitution,* and *deletion*), greater variability in percentage agreement was found as compared to those of the *correct* and *gliding* categories. First, *nasalization* showed the least percentage agreement between listener categorization and original categorization (50.27%). When judged as other categories other than *nasalization*, listeners commonly chose the *correct* category (39.3%), followed by *distortion* (6.16%) and *gliding* (substitution to /j/) (1.6%). The *deletion* category had a similar but slightly higher percentage agreement (51.65%). Judgment patterns within the *deletion* category included some productions being consistently categorized

as *gliding* (substitution to /j/) (17.36%) or as *distortion* (13.64%). Lastly, percentage agreement for */d/ substitution* was 71.59%. This was the highest percentage agreement among the less common errors. If not judged as */d/ substitution*, these productions were commonly categorized as *correct*. Percentage agreement for all categories is shown in Table 4.1. The "other substitution" category refers to listeners' responses including a substitution error other than gliding, nasalization, or /d/ substitution (e.g., glottal substitution).

Table 4.1. Percentage agreement by original category and listener responses.

	Original Category				
Listener Responses	**Correct**	**Gliding**	**Nasalization**	**/d/ substitution**	**Deletion**
Correct	**94.78**	12.34	39.3	15.53	11.16
Gliding	0.34	**82.95**	1.6	0	17.36
Nasalization	0.67	0	**50.27**	6.06	0.41
/d/ substitution	0	0	0	**71.59**	0.41
Deletion	0.51	1.62	2.14	0.76	**51.65**
Distortion	2.86	1.95	6.15	3.79	13.64
Other	0.84	1.14	0.53	2.27	4.96
Other Substitution	0	0	0	0	0.41

VAS Task

For the VAS task, ratings for each original category are depicted in Figure 4.1. The curve of this density plot shows the proportion of values, and peaks show where values are concentrated.

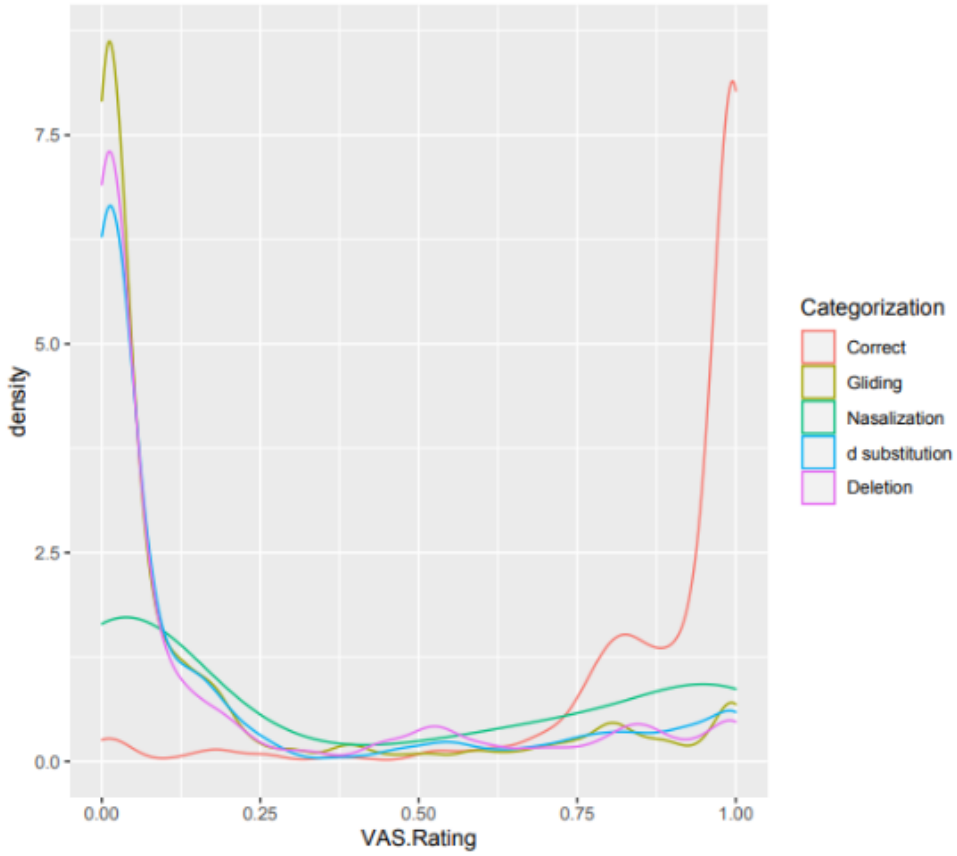

Figure 4.1. Density plot of VAS ratings by original category. VAS rating of "0" represents "I heard the /l/ sound produced incorrectly" and "1" represents "I heard the /l/ sound produced correctly."

As can be observed in Figure 4.1, the *correct* category had high density peaks closest to 1, indicating that most listeners rated productions in this category as acceptable productions of /l/ and showed little variability between listeners (mean: 0.89, median: 0.99, SD: 0.20). For the *gliding* category, the peak was near 0, indicating that most listeners rated these productions as unacceptable productions of /l/. These responses also showed less variability among listeners (mean: 0.17, median: 0.03, SD: 0.29). Categories *deletion* and */d/ substitution* also had peaks near 0 but showed slightly more variability in listeners' ratings than the *correct* and *gliding* categories (*deletion*: mean: 0.17, median: 0.02, SD: 0.30; */d/ substitution:* mean: 0.18, median: 0.03, SD: 0.31). Lastly, the *nasalization* category showed the greatest variation, with some

concentration both near VAS ratings 0 and 1, indicating that there was the least agreement among listeners as compared to the other categories (mean: 0.40, median: 0.16, SD: 0.41). In other words, some listeners rated the nasalized productions as completely acceptable productions of /l/, some rated the productions as completely unacceptable, and some rated the productions as in between acceptable and unacceptable.

The statistical analysis confirmed these observations. The results of the Kruskal-Wallis test showed that there are significant differences in VAS rating among the categories ($p < 0.05$). Specifically, the pairwise Wilcox test showed that VAS ratings of *correct* category differ significantly from all the other categories ($p < 0.05$), and those of *nasalization* category also differed significantly from the rest of the other categories ($p < 0.05$).

For interrater reliability, the ICC ratings for each category were lower for *correct* (0.06), *gliding* (0.14), *nasalization* (0.31), and *deletion* (0.14) categories than for */d/ substitution* (0.53). Lower interrater reliability could be explained by one or two listeners selecting very binary responses or due to some stimuli being intermediate productions that were in between the target sound and other error sounds.

Treatment Methods Used to Treat Less Common Error Patterns of /l/

The descriptive analysis of SLPs' responses on treatment methods for less common errors involving /l/ showed that the most frequently used method was placement cues, followed by the repetition/drill and phonological methods. These results are summarized in Figure 4.2.

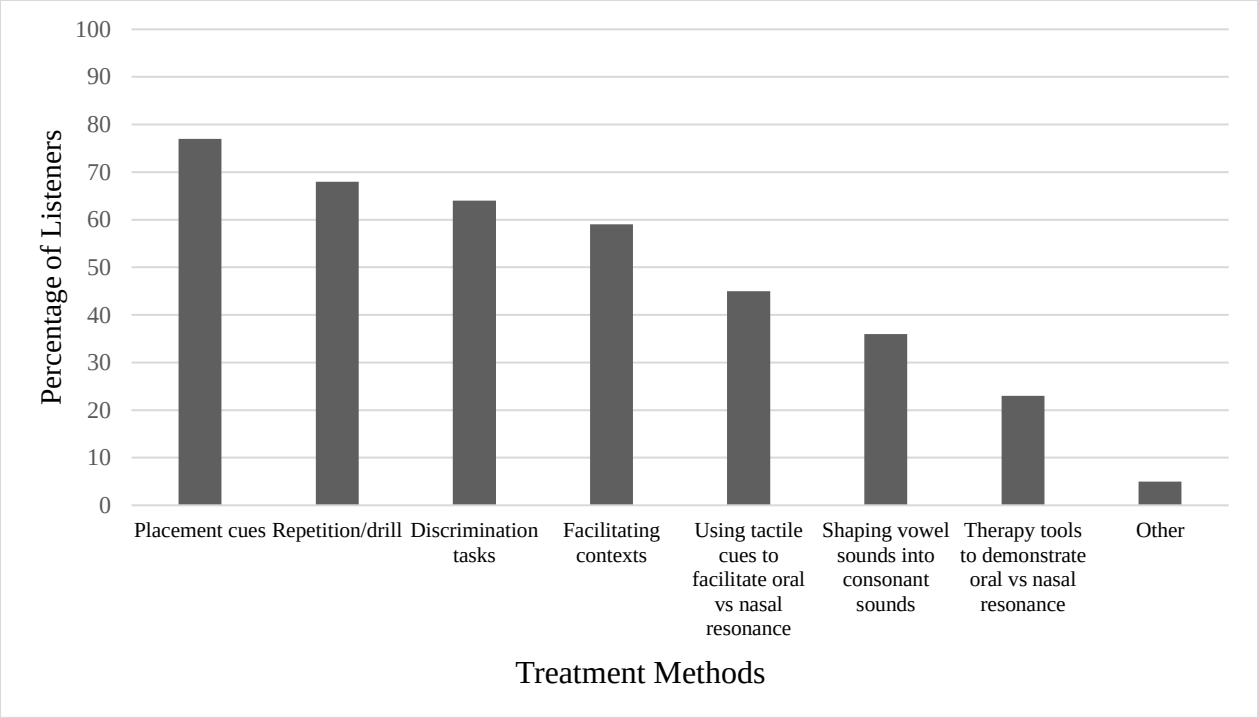

Figure 4.2. Treatment methods for less common errors of /l/ by percentage of listeners who selected each response.

For the treatment methods for each type of error, the most frequently selected method for nasalized productions was *placement cues* (selected by 47% of listeners), followed by *therapy tools to demonstrate oral vs nasal resonance* (43% of listeners) and *discrimination tasks* (41% of listeners). Overall, 41% of listeners selected a combination of both phonetic-based and phonological methods (e.g., selection of placement cues, discrimination tasks, and other methods specific to nasalization).

For productions where /d/ was substituted for /l/, 80% of listeners selected *placement cues* as a treatment method, followed by *discrimination tasks* (66% of listeners) and *facilitating contexts* (43% of listeners). Additionally, 66% of listeners selected methods that were both phonological- and phonetic-based. Lastly, for the *deletion* category, the most frequently selected treatment method was *placement cues* (selected by 100% of listeners), followed by *discrimination tasks* (59% of listeners), and *facilitating contexts* (45% of listeners). Thirteen out

of 22 listeners (59%) selected multiple methods that were both phonetic-based and phonological-based methods. There was one listener who selected both *placement cues* and *discrimination tasks* and also selected the *Other* option, reporting that they would use "phonological awareness tasks to teach awareness of initial consonants" to treat this type of atypical error.

Chapter 5. Discussion

The aim of the current study was to better understand different error patterns of /l/ in children and speech-language pathologists' perception and treatment of these errors. The first research question examined a) error patterns of /l/ produced by children that differ from common phonological processes and b) whether experienced SLPs showed consistency in accuracy judgment of these less common errors.

Types of Less Common Errors

Examination of children's less common /l/ errors show that these errors can be categorized into three different patterns: *word-initial /l/ deletion, nasalization*, and *substitution of /d/ for /l/.* Word-initial consonant deletion has been frequently reported in studies involving atypical error patterns (e.g., Dodd, 2011; Dodd & Iacano, 1989; Preston & Edwards, 2010). Additionally, nasalization has been cited as a type of "atypical change," specifically an "atypical manner of articulation change" (e.g., Brosseau-Lapre & Roepke, 2019; Macrae & Tyler, 2014; Preston & Edwards, 2010), which can be associated with weak underlying phonological representations and impaired PA skills (Anthony et al., 2010; Brosseau-Lapre & Roepke, 2019; Preston & Edwards, 2010). As for /d/ substitution, it has been reported that children do frequently produce this error and that it can be explained by gestural omission involving the loss of a posterior gesture, resulting in a [d]-like tongue shape (e.g., Gick et al., 2007; Howson & Redford, 2019, 2021). However, there has not been a study that has reported an exact percentage of children who produce this error. Therefore, it is unclear whether this error is an example of an atypical error or a less common developmental error that can be explained by articulatory simplification, like other common, developmental errors.

Listener Perception of Less Common Error Patterns

As for SLPs' perception of different /l/ error patterns, it was hypothesized that SLPs would show greater variability in their accuracy judgment and VAS ratings of less common error patterns of /l/ as compared to the perception of acceptable productions due to /l/ being subject to perceptual confusion and children's intermediate productions. As predicted, listeners were more consistent in their judgment of *correct* productions as demonstrated by a high percentage agreement for the multiple-choice task and high density peaks closest to 1 for the VAS distribution. Additionally, results showed that the *gliding* category also had a high percentage agreement for the multiple-choice task and a peak near 0 on the VAS distribution, indicating that most listeners rated these productions as unacceptable productions of /l/ and showed less variability among listeners.

As for the less common error patterns *(nasalization, /d/ substitution, and deletion*), as predicted, there was greater variability in accuracy judgments and VAS ratings for all three less common error types compared to correct productions. In comparison to the correct and gliding productions, *deletion* and */d/ substitution* categories demonstrated lower percentage match and some variability in listeners' VAS ratings. Specifically, the greatest variability in perception was found for nasalized productions. The *nasalization* category showed the lowest percentage agreement with the original multiple-choice category, and its VAS pattern showed the most widespread pattern, which indicates that there was the least agreement among listeners as compared to the other categories. One possible explanation of this low agreement among listeners for nasalized /l/ productions could be related to the place of articulation of the two sounds; both /l/ and /n/ are produced with constriction at the alveolar ridge, with the back cavity behind the constriction generating antiresonance, and thus affecting its acoustic patterns (Fant, 1960).

Additionally, the lower percentage of agreements for less common errors could be related to listeners' awareness involving less common errors of /l/. Unlike gliding, which is frequently discussed as a type of error for /l/ (e.g., Haelsig & Madison, 1986; Hodson & Paden, 1981; Peña-Brooks & Hegde, 2015; Preisser et al., 1988; Shipley & McAfee, 2016), other types of errors discussed in this study are rarely discussed in the literature, specifically in pedagogical materials, making listeners less familiar with these error types. This could have resulted in less consistency in their perceptual judgment of less common errors. For example, the results showed that less common error productions containing nasalization and deletion were commonly categorized as distorted by listeners. This could suggest that when listeners are uncertain about the types of errors, they were more inclined to categorize them as distorted rather than using other categories. Furthermore, there have been instances where the same sound has been categorized differently by SLPs although the notes provided by SLPs indicate that they have perceived similar error patterns (either nasalization or deletion).

These findings suggest that more discussion on types of different error patterns involving /l/ sounds, other than commonly discussed gliding patterns, could help listeners become more familiar with the types of less common errors and help them be consistent in their perception. Perceptual consistency is important clinically for accurate assessment of children's speech sounds. Consistent clinical perception is especially important for identifying children who are producing less common errors, as these children may have poor phonological representations and PA skills, putting them at risk for difficulty with acquiring literacy (e.g., Anthony et al., 2010; Brosseau-Lapre & Roepke, 2019; Dodd, 2005; Leitão & Fletcher, 2004; Nathan et al., 2004; Raitano et al., 2004). Perceptual training that includes various examples of less common errors

could be helpful in training listeners on different types of errors, which could increase consistency in their perceptual judgment of less common speech errors.

In addition, there is a need for more consistent terms for classifying nasalization, deletion, and other substitutions other than gliding errors. Terminology regarding atypical and non-developmental errors are often used interchangeably in the literature to describe less common error patterns; however, the criteria that classify these errors varies across studies. Non-developmental errors are often defined as errors that differ from commonly used developmental phonological processes (e.g., Leitão & Fletcher, 2004). Atypical errors are defined as errors that are rarely produced by children of any age, in comparison to typical errors, which are produced by at least 5% or 10% of children at any age (e.g., Dodd et al., 2018; Smit et al., 1990). More consistent terminology regarding atypical errors could help improve clinicians' recognition of these errors and aid in identifying children that may be at risk for difficulties that are often associated with these errors.

Treatment of Less Common Errors

As predicted, the results of the current study showed that clinicians use a combination of many different methods to treat less common errors. These include phonological methods and production-based methods that target the articulation of the sound. However, not all clinicians selected phonological treatment methods, despite these methods being recommended for the treatment of atypical errors (e.g., Dodd & Iacano, 1989; Leonard & Brown, 1984; Preston & Edwards, 2010). Additionally, none of the SLPs suggested to screen or assess children's PA skills. Considering that children who produce atypical errors are likely to have weak PA skills, PA screenings or assessments for children suspected to produce atypical errors would be beneficial in identifying impairments in phonological awareness, which is important as they can

have long-term effects on their literacy skills (Brosseau-Lapre & Roepke, 2019; Preston & Edwards, 2010). In order to improve production of target sounds as well as PA, it could be recommended to target both speech sound production and PA during treatment of children who produce atypical errors (Gillon, 2005; Preston & Edwards, 2010).

Overall, SLPs showed differing opinions on the types of methods they would use to treat less common errors of /l/. More literature regarding the treatment of less common speech errors, therefore, could be helpful in providing the most effective intervention plans for this population of children.

Conclusion

The aim of the current study was to better understand types of less common errors of /l/ in children and SLPs' perception and treatment of these errors. This study identified three types of less common errors of /l/*: word-initial /l/ deletion, nasalization, and /d/ substitution.* This study also showed that that there is variability in SLPs' perception and treatment methods for these less common errors. This demonstrates the need for more consistent terminology, comprehensive literature, and perceptual training regarding less common speech errors involving frequently misarticulated sounds such as /l/. This will be helpful in increasing clinicians' awareness of these errors, enhancing consistency in listeners' clinical judgment of these errors, and providing guidance for effectively treating these errors.

Limitations and Future Directions

Although the current study aimed to include varied stimuli, there was a limited number of stimuli, specifically for less common error productions, which was related to the number of child speakers. Future studies should include a larger number of child speakers to increase the number of productions per pattern and increase the reliability of the results. Secondly, although various

attempts were made to include many listeners from a wide range of cities and states, there was a limited number of SLPs who served as listeners in the current study. Additionally, most of the listeners were from one state, Louisiana. Future studies should include a larger number of listeners from different cities and states to better generalize the results by including listeners of different dialects.

Appendix A. Questionnaire

1. Do you have any history of speech and language problems? If yes, what type and have they been resolved?

a. Yes

b. No

2. Do you have a history of hearing difficulties? If yes, what type and have they been resolved?

a. Yes

b. No

3. Please specify how many years you have worked as a speech language pathologist:

4. Where have you practiced as a speech-language pathologist and for how long? Indicate the city and state/country (if not US) you practiced and the duration (e.g., if you have 2 years and 6 months of experience, please write 2;6).

• Location 1:

- City:

- State/Country:

- Duration:

• Location 2:

- City:

- State/Country:

- Duration:

• Location 3:

- City:

- State/Country:

- Duration:

5. Please select the background of populations you have worked with (select all that apply):

a: Pediatric patients (e.g., articulation, language, social communication)

b. Adult patients (e.g., cognitive communication disorders, language impairments, motor speech disorders)

c. Other:

6. Please select the clinical settings you have worked in (select all that apply):

a. School system

b. Private practice

c. Hospital

d. Nursing home

e. Other

7. How often do you see child clients in a month?

a. Very frequently (at least 5 hours per week)

b. Often (at least 1-2 hours per week)

c. Very rarely (at least 1-2 hours per month)

d. Never

8. Please select the age range of patients you have worked with in the past 10 years (select all that apply):

a. 2 years old - Pre-k

b. K - 5th grade

c. Middle school students

d. High school students

e. Adults

9. Please select the kinds of sounds you have worked with (select all that apply):

a. Stops /p, b, t, d, k, g/

b. Fricatives /f, v, θ, ð, s, z, ʃ, ʒ, h/

c. Affricates /tʃ, dʒ/

d. Nasals /m, n, ŋ/

e. Liquids /l, r/

g. Glides /j, w/

h. Vowels

10. Have you ever encountered errors of /l/ that **differ** from gliding errors (gliding = “wamp” for "lamp")?

a. Yes

b. No

11a. How have you treated those different errors of /l/ (**/l/ errors other than gliding errors)**? Select the most appropriate/relevant option from the choices provided.

a. Placement cues (verbal, visual, tactile)

b. Discrimination tasks (e.g., minimal pairs approach)

c. Facilitating contexts (opportunity to produce /l/ correctly based on surrounding phonemes)

d. Repetition/drill

e. Therapy tools to demonstrate oral vs. Nasal resonance

f. Shaping vowel sounds into consonant sounds

g. Using tactile cues to facilitate oral vs nasal resonance

h. Other

11b. How would you treat different errors of /l/ (**/l/ errors other than gliding errors**)? Select the most appropriate/relevant option from the choices provided.

a. Placement cues (verbal, visual, tactile)

b. Discrimination tasks (e.g., minimal pairs approach)

c. Facilitating contexts (opportunity to produce /l/ correctly based on surrounding phonemes)

d. Repetition/drill

e. Therapy tools to demonstrate oral vs. Nasal resonance

f. Shaping vowel sounds into consonant sounds

g. Using tactile cues to facilitate oral vs nasal resonance

h. Other

12. Please provide your email address for compensation purposes:

Appendix B. Participant Background cont.

Table B.1 Participant background cont.

Participant ID	City/States practiced and duration (years; months)	Backgrounds of populations worked with	Clinical settings worked in
L01	Laurel, MS - 7; Hattiesburg, MS - 5; Baton Rouge, LA - 9	Pediatric, Adult	School system, Private Practice, Hospital, Nursing Home
L02	Gonzales, LA - 3; Prairieville, LA - 19; Donaldsonville, LA - 1	Pediatric	School system, Private Practice, Other: virtual
L03	Hammond, LA - 5;5; Loranger, LA - 19;5	Pediatric	School system
L04	Gonzales, LA - 20; Baton Rouge, LA - 8; Nashville, TN - 2	Pediatric, Adult	School system, Private Practice, Hospital, Nursing Home
L05	Florence, TX - 1; Navarre, FL - 1;5	Pediatric	School system, Private Practice, Other: Home Health
L06	Elk Grove Village, IL - 14; Chicago, IL - 14	Pediatric, Adult	Hospital, Other: University clinic
L07	Milwaukee, WI - 0;11; Minneapolis, MN - 5;2; Chicago, IL - 7	Pediatric, Adult, Other: Primarily adults, with a very small pediatric caseload	Hospital, Other: University clinic
L08	Chicago, IL - 38	Pediatric	School system, Other: University Clinic
L09	Folsom, LA - 7;6; Metairie, LA - 24	Pediatric	School system, Private Practice
L10	Oak Lawn, IL - 15; Oak Forest, IL - 15; Chicago, IL - 10	Pediatric, Adult	School system, Other
L11	Hammond, LA – 1; Raleigh, NC - 0;8	Pediatric, Adult	Private Practice, Hospital
L12	Donaldsonville, LA – 3; Gonzales, LA - 20	Pediatric	School system
L13	Kentwood, LA - 2; Hammond, LA - 2; Ponchatoula, LA - 15	Pediatric	School system
L15	New Orleans, LA – 7; Metairie, LA - 14	Pediatric	School system, Privative Practice, Hospital
L16	Covington, LA – 27; Belton, TX - 1;6; Hilo, HI – 1	Pediatric, Adult	School system, Hospital, Nursing Home, Other: Private Clinic

(table cont'd.)

Participant ID	City/States practiced and duration (years; months)	Backgrounds of populations worked with	Clinical settings worked in
L17	Baton Rouge, LA - 27; Marksville, LA - 2	Pediatric, Adult	School system, Private Practice, Hospital, Nursing Home
L18	Denham Springs, LA – 15; Baton Rouge, LA - 14	Pediatric, Adult, Other: Dysphagia	School system, Private Practice, Hospital, Nursing Home, Other: University
L20	Denham Springs, LA - 1;10; Baton Rouge, LA - 0;8; Walker, LA - 0;9	Pediatric, Adult	School system, Private Practice, Nursing Home
L23	Gonzales, LA – 8; Spring, TX – 5; Baton Rouge, LA - 1	Pediatric	School system, Other: Self-Employed
L24	Various cities , KY – 4; Various cities, IL - 6	Pediatric, Adult	School system, Private Practice, Hospital, Other: University clinic; public and private schools
L27	Brookhaven, MS – 20; Franklinton, LA - 2	Pediatric, Adult	School system, Private Practice, Hospital, Nursing Home
L28	San Jose, CA - 5	Pediatric	School system

Appendix C. Institutional Review Board Approval

LSU | Office of Research & Economic Development

TO:	Hyunju Chung LSUAM | Col of HSS | Communication Sciences and Disorders | CC00127
FROM:	Alex Cohen Chairman, Institutional Review Board
DATE:	10-Jan-2024
RE:	IRBAM-23-1254
TITLE:	Different Error Patterns of /l/ in Children and Speech-Language Pathologists' Perception and Treatment
SUBMISSION TYPE:	Initial Application
Review Type:	Expedited Review
Risk Factor:	Minimal
Review Date:	10-Jan-2024
Status:	Approved
Approval Date:	10-Jan-2024
Approval Expiration Date:	09-Jan-2025
Expedited Categories:	07
Requesting Waiver of Informed Consent:	Yes
Re-review frequency:	Annually
Number of subjects approved:	50
LSU Proposal Number:	
By:	Alex Cohen, Chairman

Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation.**

** All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/research*

Louisiana State University
131 David Boyd Hall

O 225-578-5833
F 225-578-5983

Bibliography

American Speech-Language-Hearing Association. (2015, July 2). *Selected phonological processes (patterns)*. https://www.asha.org/practice-portal/clinical-topics/articulation-and-phonology/selected-phonological-processes/

Anthony, J. L., Williams, J. M., Aghara, R. G., Dunkelberger, M., Novak, B., & Mukherjee, A. D. (2010). Assessment of individual differences in phonological representation. *Reading and Writing*, *23*(8), 969-994. https://doi.org/10.1007/s11145-009-9185-7

Baum, S. R., & Mcnutt, J. C. (1990). An acoustic analysis of frontal misarticulation of /s/ in children. *Journal of phonetics*, *18*, 51-63. https://doi.org/10.1016/S0095-4470(19)30358-4

Bernstein, S. R. (2015). *Individual differences in the acquisition of the /t/-/k/ contrast: A study of adults' perception of children's speech* [Doctoral Dissertaion, University of Minnesota]. University of Minnesota Digital Conservancy.

Boersma, P., & Weenink, D. (2023). *Praat: doing phonetics by computer* [Computer program]. Version 6.3.08, retrieved 10 February 2023 from http://www.praat.org/

Broomfield, J., & Dodd, B. (2005). Clinical effectiveness. In B. Dodd (Ed.), *Differential diagnosis and treatment of children with speech disorder* (pp. 211-230). Whurr.

Brosseau-Lapre, F., & Roepke, E. (2019). Speech errors and phonological awareness in children ages 4 and 5 years with and without speech sound disorder. *Journal of Speech, Language, and Hearing Research*, *62*(9), 3276-3289. https://doi.org/10.1044/2019_JSLHR-S-17-0461

Browman, C., & Goldstein, L. (1989). Articulatory gestures as phonological units. *Phonology*, *6*(2), 201-251. https://doi.org/10.1017/S0952675700001019

Chung, H. (2020). Acquisition and acoustic patterns of Southern American English /l/ in young children. *Journal of Speech, Language, and Hearing Research*, *63*(8), 2609-2624. https://doi.org/10.1044/2020_JSLHR-19-00040

Chung, H., Lemoine, G. E., Sanders, J. B., & Schellinger, S. K. (2023). Effect of speaker age on listener perception of word-final /l/. *Journal of Speech, Language, and Hearing Research*, *66*(3), 916-930. https://doi.org/10.1044/2022_JSLHR-22-00437

Chung, H., & Weismer, G. (2021). Formant trajectory patterns of American English /l/ produced by adults and children. *Journal of Speech, Language, and Hearing Research*, *64*(3), 809-822. https://doi.org/10.1044/2020_JSLHR-20-00345

Coplan, J., & Gleason, J. R. (1988). Unclear speech: Recognition and significance of unintelligible speech in preschool children. *Pediatrics*, *82*(3), 447-452. https://www.ncbi.nlm.nih.gov/pubmed/3405680

Dalston, R. M. (1975). Acoustic characteristics of English /w,r,l/ spoken correctly by young children and adults. *Journal of the Acoustical Society of America*, *57*(2), 462-467. https://doi.org/10.1121/1.380469

De´ak, G. (2003). The development of cognitive flexibility and language abilities. *Advances in Child Development and Behavior*, *31*, 271-327.

DeWitt, A. (2019). *Nondevelopmental phonological processes*. Handy Handouts. https://www.handyhandouts.com/viewHandout.aspx?hh_number=599

Dodd, B. (2005). *Differential diagnosis and treatment of children with speech disorder*. Whurr.

Dodd, B. (2011). Differentiating speech delay from disorder: Does it matter?. *Topics in Language Disorders*, *31*(2), 96-111. https://doi.org/10.1097/TLD.0b013e318217b66a

Dodd, B. (2013). *Differential diagnosis and treatment of children with speech disorder*. John Wiley & Sons.

Dodd, B., Hua, Z., & Shatford, C. (2000). Does speech disorder spontaneously resolve?. *Current Research in Language and Communication Science*, *1*, 3-10.

Dodd, B., & Iacano, T. (1989). Phonological disorders in children: Changes in phonological process use during treatment. *International Journal of Language and Communation Disorders*, *24*(3), 333-352. https://doi.org/10.3109/13682828909019894

Dodd, B., Leahy, J., & Hambly, G. (1989). Phonological disorders in children: Underlying cognitive deficits. *British Journal of Developmental Psychology*, *7*(1), 55-71. https://doi.org/10.1111/j.2044-835X.1989.tb00788.x

Dodd, B., Ttofari-Eecen, K., Brommeyer, K., Ng, K., Reilly, S., & Morgan, A. (2018). Delayed and disordered development of articulation and phonology between four and seven years. *Child Language Teaching and Therapy*, *34*(2), 87-99. https://doi.org/10.1177/0265659017735958

Donegan, P. J., & Stampe, D. (1979). The study of natural phonology. In D. A. Dinnsen (Ed.), *Current approaches to phonological theory* (pp. 126-173). https://doi.org/10.2979/CurrentApproachestoP

Dyson, A. T. (1988). Phonetic inventories of 2- and 3-year-old children. *Journal of Speech and Hearing Disorders*, *53*(1), 89-93. https://doi.org/10.1044/jshd.5301.89

Edwards, M. L., & Shriberg, L. D. (1983). *Phonology: Applications in communicative disorders*. College-Hill Press.

Fant, G. (1960). *Acoustic theory of speech production*. Mouton.

Gick, B. (1999). *The articulatory basis of syllable structure: a study of English glides and liquids* [Doctoral thesis, Yale University].

Gick, B., Bacsfalvi, P., Bernhardt, B. M., Oh, S., Stolar, S., & Wilson, I. (2007). A motor differentiation model for liquid substitutions in children's speech. 153rd Meeting Acoustical Society of America, Salt Lake City, Utah.

Gillon, G. T. (2005). Facilitating phoneme awareness development in 3- and 4-year-old children with speech impairment. *Language, Speech, and Hearing Services in Schools*, *36*(4), 308-324. https://www.ncbi.nlm.nih.gov/pubmed/16389703

Haelsig, P. C., & Madison, C. L. (1986). A study of phonological processes exhibited by 3-, 4-, and 5-year-old children. *Language, Speech, and Hearing Services in Schools*, *17*(2), 107-114. https://doi.org/10.1044/0161-1461.1702.107

Hardcastle, W., & Barry, W. (1989). Articulatory and perceptual factors in /l/ vocalisations in English. *Journal of the International Phonetic Association*, *15*(2), 3-17. https://doi.org/10.1017/S0025100300002930

Hixon, T., Weismer, G., & Hoit, J. D. (2018). *Preclinical speech science: Anatomy, physiology, acoustics, perception* (3rd ed.). Plural Publishing, Incorporated. https://ebookcentral.proquest.com/lib/reading/detail.action?docID=5509496

Hodson, B. W., & Paden, E. P. (1981). Phonological processes which characterize unintelligible and intelligible speech in early childhood. *Journal of Speech and Hearing Disorders*, *46*(4), 369-373. https://doi.org/10.1044/jshd.4604.369

Holt, L. L., & Lotto, A. J. (2010). Speech perception as categorization. *Attention, Perception, & Psychophysics*, *72*(5), 1218-1227. https://doi.org/10.3758/APP.72.5.1218

Howson, P. J., & Redford, M. A. (2019). Liquid coarticulation in child and adult speech. *Proceedings of the International Congress of Phonetic Sciences*, *2019*, 3100-3104. https://www.ncbi.nlm.nih.gov/pubmed/31663086

Howson, P. J., & Redford, M. A. (2021). The acquisition of articulatory timing for liquids: Evidence from child and adult speech. *Journal of Speech, Language, and Hearing Research*, *64*(3), 734-753. https://doi.org/10.1044/2020_JSLHR-20-00391

Hua, Z. (2002). *Phonological development in specific contexts: Studies of Chinese-speaking children*. Multilingual Matters. https://doi.org/10.21832/9781853595899

Ingram, D. (1976). *Phonological disability in children*. Edward Arnold.

Klein, H. B., Grigos, M. I., McAllister Byun, T., & Davidson, L. (2012). The relationship between inexperienced listeners' perceptions and acoustic correlates of children's /r/ productions. *Clinical Linguistics & Phonetics*, *26*(7), 628-645. https://doi.org/10.3109/02699206.2012.682695

Klein, H. B., & Spector, C. C. (1985). Effect of syllable stress and serial position on error variability in polysyllabic productions of speech-delayed children. *Journal of Speech and Hearing Disorders*, *50*(4), 391-402. https://doi.org/10.1044/jshd.5004.391

Leitão, S., & Fletcher, J. (2004). Literacy outcomes for students with speech impairment: Long-term follow-up. *International Journal of Language and Communation Disorders*, *39*(2), 245-256. https://doi.org/10.1080/13682820310001619478

Leitão, S., Fletcher, J., & Hogben, J. (2000). Speech impairment and literacy difficulties: Underlying links. *The Educational and Developmental Psychologist*, *17*(1), 63-75. https://doi.org/10.1017/S0816512200028030

Leitão, S., Hogben, J., & Fletcher, J. (1997). Phonological processing skills in speech and language impaired children. *International Journal of Language and Communation Disorders*, *32*(2), 91-111. https://doi.org/10.1111/j.1460-6984.1997.tb01626.x

Leitão, S., Hogben, J., & Fletcher, J. (1998). Does speech impairment mean later literacy difficulties? *Proceedings of the 1998 Speech Pathology Australia National Conference*, Fremantle, Western Australia.

Leonard, L. B. (1973). The nature of deviant articulation. *Journal of Speech and Hearing Disorders*, *38*(2), 156-161. https://doi.org/10.1044/jshd.3802.156

Leonard, L. B. (1985). Unusual and subtle phonological behavior in the speech of phonologically disordered children. *Journal of Speech and Hearing Disorders*, *50*(1), 4-13. https://doi.org/10.1044/jshd.5001.04

Leonard, L. B., & Brown, B. L. (1984). Nature and boundaries of phonologic categories: A case study of an unusual phonologic pattern in a language-impaired child. *Journal of Speech and Hearing Disorders*, *49*(4), 419-428.

Lin, S., & Demuth, K. (2015). Children's acquisition of English onset and coda /l/: Articulatory evidence. *Journal of Speech, Language, and Hearing Research*, *58*(1), 13-27. https://doi.org/10.1044/2014_JSLHR-S-14-0041

Lowe, R. J. (1994). *Phonology: Assessment and intervention applications in speech pathology*. Williams & Wilkins.

Macken, M. A., & Barton, D. (1980). The acquisition of the voicing contrast in English: study of voice onset time in word-initial stop consonants. *Journal of Child Language*, *7*(1), 41-74. https://doi.org/10.1017/S0305000900007029

Macrae, T., & Tyler, A. A. (2014). Speech abilities in preschool children with speech sound disorder with and without co-occurring language impairment. *Language, Speech, and Hearing Services in Schools*, *45*(4), 301-313. https://doi.org/10.1044/2014_LSHSS-13-0081

Marshalla, P. (2011, August 9). Nasalized /l/ and /r/. Marshalla Speech & Language. https://pammarshalla.com/nasalized-l-and-r/

Marshalla, P. (2012, April 12). Substituting /n/ for /l/. Marshalla Speech & Language. https://pammarshalla.com/substituting-n-for-l/

McAllister Byun, T., Harel, D., Halpin, P. F., & Szeredi, D. (2016). Deriving gradient measures of child speech from crowdsourced ratings. *Journal of Communication Disorders*, *64*, 91-102. https://doi.org/10.1016/j.jcomdis.2016.07.001

McLeod, S., & Crowe, K. (2018). Children's consonant acquisition in 27 languages: A cross-linguistic review. *American Journal of Speech-Language Pathology*, *27*(4), 1546-1571. https://doi.org/10.1044/2018_AJSLP-17-0100

Meyer, M. K., & Munson, B. (2021). Clinical experience and categorical perception of children's speech. *International Journal of Language and Communation Disorders*, *56*(2), 374-388. https://doi.org/10.1111/1460-6984.12610

Munson, B., Edwards, J., Schellinger, S. K., Beckman, M. E., & Meyer, M. K. (2010). Deconstructing phonetic transcription: Covert contrast, perceptual bias, and an extraterrestrial view of Vox Humana. *Clinincal Linguistics & Phonetics*, *24*(4-5), 245-260. https://doi.org/10.3109/02699200903532524

Narayanan, S. S., Alwan, A. A., & Haker, K. (1997). Toward articulatory-acoustic models for liquid approximants based on MRI and EPG data. Part I. The laterals. *The Journal of the Acoustical Society of America*, *101*(2), 1064-1077. https://doi.org/10.1121/1.418030

Nathan, L., Stackhouse, J., Goulandris, N., & Snowling, M. J. (2004). The development of early literacy skills among children with speech difficulties: A test of the "critical age hypothesis". *Journal of Speech, Language, and Hearing Research*, *47*(2), 377-391. https://www.ncbi.nlm.nih.gov/pubmed/15157138

O'Connor, J. D., Gerstman, L. J., Liberman, A. M., Delattre, P. C., & Cooper, F. S. (1957). Acoustic cues for the perception of initial /w, j, r, l/ in English. *Word*, *13*(1), 24-43. https://doi.org/10.1080/00437956.1957.11659626

Peña-Brooks, A., & Hedge, M. N. (2007). *Assessment and treatment of articulation and phonological disorders in children*. PRO-ED.

Peña-Brooks, A., & Hegde, M. N. (2015). *Assessment and treatment of speech sound disorders in children: A dual-level text*. PRO-ED.

Preisser, D. A., Hodson, B. W., & Paden, E. P. (1988). Developmental phonology: 18-29 months. *Journal of Speech and Hearing Disorders*, *53*(2), 125-130. https://doi.org/10.1044/jshd.5302.125

Preston, J., & Edwards, M. L. (2010). Phonological awareness and types of sound errors in preschoolers with speech sound disorders. *Journal of Speech, Language, and Hearing Research*, *53*(1), 44-60. https://www.ncbi.nlm.nih.gov/pubmed/19717651

Preston, J. L., Hull, M., & Edwards, M. L. (2013). Preschool speech error patterns predict articulation and phonological awareness outcomes in children with histories of speech sound disorders. *American Journal of Speech-Language Pathology*, *22*(2), 173-184.

R Core Team. (2023). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing. https://www.R-project.org/

Raitano, N. A., Pennington, B. F., Tunick, R. A., Boada, R., & Shriberg, L. D. (2004). Pre-literacy skills of subgroups of children with speech sound disorders. *Journal of Child Psychology and Psychiatry*, *45*(4), 821-835. https://doi.org/10.1111/j.1469-7610.2004.00275.x

Shipley, K. G., & McAfee, J. G. (2016). *Assessment in speech-language pathology: a resource manual* (5th ed.). Cengage Learning.

Shriberg, L. D. (1993). Four new speech and prosody-voice measures for genetics research and other studies in developmental phonological disorders. *Journal of Speech, Language, and Hearing Research*, *36*(1), 105-140. https://doi.org/10.1044/jshr.3601.105

Smit, A. B., Hand, L., Freilinger, J. J., Bernthal, J. E., & Bird, A. (1990). The Iowa Articulation Norms Project and its Nebraska replication. *Journal of Speech and Hearing Disorders*, *55*(4), 779-798. https://doi.org/10.1044/jshd.5504.779

Snowling, M., Bishop, D. V., & Stothard, S. E. (2000). Is preschool language impairment a risk factor for dyslexia in adolescence?. *Journal of Child Psychology and Psychiatry*, *41*(5), 587-600. https://doi.org/10.1111/1469-7610.00651

Sproat, R., & Fujimara, O. (1993). Allophonic variation in English /l/ and its implications for phonetic implementation. *Journal of phonetics*, *21*(3), 291-311. https://doi.org/10.1016/S0095-4470(19)31340-3

Stackhouse, J., & Wells, B. (1997). *Children's speech and literacy difficulties: A psycholinguistic framework*. Whurr.

Stark, R. E. (1980). Stages of speech development in the first year of life. In *Child phonology* (pp. 73-92). Academic Press. https://doi.org/10.1016/B978-0-12-770601-6.50010-3

Templin, M. C. (1957). *Certain language skills in children: Their development and interrelationships*. University of Minnesota Press.

To, C. K. S., McLeod, S., Sam, K. L., & Law, T. (2022). Predicting which children will normalize without intervention for speech sound disorders. *Journal of Speech, Language, and Hearing Research*, *65*(5), 1724-1741. https://doi.org/10.1044/2022_JSLHR-21-00444

Van Riper, C. (1939). *Speech correction: Principles and methods*. Prentice Hall.

Winn, M. B. (2020). *Scale intensity of all sounds in a directory* [Praat script]. Retrieved from https://raw.githubusercontent.com/ListenLab/Praat/master/Scale_intensity_all_sounds_in_folder_v1.txt

Vita

Grace Lemoine graduated from Louisiana State University in May 2022 with a bachelor's degree in Communication Disorders and a minor in Psychology. Grace presented her undergraduate research at the LSU Discover Day Undergraduate Research and Creativity Symposium in April 2022 and at the Annual Convention of the American Speech-Language-Hearing Association (ASHA) in November 2022. She anticipates graduating with a master's degree in Communication Disorders in May 2024. Upon completion of her master's degree, Grace plans to complete her clinical fellowship and become a certified speech-language pathologist. She aspires to work with the pediatric population to help children with their speech, language, and feeding abilities.