5-2023

Comparing Speech Sound Production Skills across Two-Year Olds with Varying Language Proficiency using Phonetic Inventory and Word-Shape Complexity

Makayla Eberly

Comparing Speech Sound Production Skills across Two-Year Olds with Varying Language Proficiency using Phonetic Inventory and Word-Shape Complexity

Makayla Eberly

College of Education, Health, & Human Sciences

Department of Special Education and Communication Disorders

May 2023

Table of Contents

Abstract

Purpose. Young children, who by the time they are two years of age, have 50 or fewer words in their expressive lexicon and produce few to no two-words phrases are often identified as demonstrating "late language emergence" (LLE). The nature of the relationship between speech sound (phonological) production development and LLE continues to be an important area of inquiry in the field of speech-language pathology with clinical intervention implications. The present study aimed to further distinguish and confirm associations between phonological productions and language proficiency status at two years of age.

Method. Participants (n = 20) were divided into two attributional condition groups: those with LLE and those presenting with typical language development. Data collected as part of an ongoing study were analyzed including phonetic inventory and word-shape complexity data for each participant.

Results. Descriptive and inferential statistics were utilized to analyze study data and indicated significant differences between the condition groups regarding phonetic inventory and word shape complexity such that those with LLE generally produced fewer total sounds across word positions, fewer total consonant clusters across word positions, fewer singleton initial productive sounds, and fewer singleton final productive sounds. Those with LLE also generally produced fewer different word shapes and had fewer multisyllabic word productions.

Conclusion. In support of previous empirical findings, the present study findings of a positive correlation between phonological productions and language proficiency further indicated the bidirectional relationship of language and speech development during the toddler years.

Chapter I: Introduction

By the age of two-years old, children may be identified with late language emergence (LLE) if they are exhibiting the use of a small expressive vocabulary with few to no connected phrases without the presence of other developmental disorders (Zubrick et al. 2007). LLE status may be associated with multiple possible predicting factors, including limited expressive and receptive vocabulary and low socioeconomic status (Fisher, 2017).

LLE is a language impairment; as such, children with LLE are more likely to demonstrate deficits in phonological skills, the ability to consistently and accurately use a wide variety of individual meaningful sounds in a language, than peers with typical development (Williams & Elbert, 2003). Because of this connection between the two skill sets, phonological skills may serve as an indicator of language development status in two-year-old children (i.e., toddlers).

Further, the procedural memory system is closely tied to the acquisition of language (Ullman & Pierpont, 2005) and motor-skill learning (Krishnan et al., 2016). Impairment of both motor and language often present together and may be related and/or caused by the same factor(s) (Bishop et al., 2016). The motor domain of procedural motor learning and the language domain of phonological production warrant further investigation in two-year-old children to better understand the bidirectional connections between early language and motor skills as well as phonology and overall language skill development in children who present with LLE.

Young children with a language impairment are more likely to use simple syllable shapes in words (e.g., “wa” for “water”) than their peers who have typical language development. These differences may persist throughout early childhood (Pharr & Ratner, 2000). Literature also suggests that children with less complex syllable structures used in words and fewer consonantal types of sound production in their speech sound repertoire are more likely to be identified with

LLE (Fasolo et al., 2009). To better understand this relationship as a risk factor for diagnosis of LLE, further empirical evidence is necessary. To target this area of language, an informal word-shape complexity inventory (a collection of word shapes produced in speech which increase in complexity as the number of consonant-vowel combinations increase) can be collected. For example, the production of "wa" would be coded as "CV," while the production of "want" would be coded as "CVCC."

To advance research in this area, the current project aimed to compare two year olds who have been identified as presenting with LLE with their peers who show typical expressive language development by exploring speech sound production skills through informal assessment tools, phonetic inventory and word-shape complexity analysis.

The present study was IRB-approved in the United States (IRB#0074-20-EP) by the University of Nebraska Medical Center/University of Nebraska at Omaha Institutional Review Board. The purpose of the study was to consider the following research question:

Is language status at two years of age associated with phonological productions, as measured by phonetic inventory and word-shape complexity?

Based on current evidence, the researchers hypothesized that children in the present study who were identified with LLE would have fewer consonant speech sounds noted in their phonetic inventories, including total singleton speech sounds emerging across all word positions, total clusters (productive and emerging) across all positions, number of singleton initial productive sounds, and number of singleton final productive sound, compared to their peers in the present study with typical language development. The researchers also hypothesized that children in the present study with LLE would produce less complex word shapes based on a word shape complexity analysis, including total word shapes utilized, number of monosyllabic

word shape productions, and number of multisyllabic word shape productions, compared to their peers in the study with typically-developing language. These hypotheses are based on existing literature in this area of the field.

Chapter II: Methodology

Participants. Participants of the study included two-year-old children already involved in an ongoing investigation led by Dr. Shari DeVeney and colleagues, *Motor skill learning across toddlers with differing language skills*. In this study, 20 English-speaking participants were recruited, and data collection concluded in June 2022. The present study involved a secondary analysis of the data collected with a focus on phonological (speech sound production) aspects. Children with (a) a diagnosis of neurological, physical, and/or sensory impairment, (b) a score higher than 11 on the Developmental Behavioral Checklist-Early Screen (DBC-ES: Gray & Tongue, 2005); this checklist was used to screen for Autism, (c) a secondary or primary language other than English were not considered for the study to control for alternative factors which may cause language impairment not being analyzed. Conversely, 2-year-old children who did not have a diagnosis of an additional impairment other than language, obtained a score of 11 or lower on the DBC-ES, and spoke English as a primary language were eligible to be included in the study.

Procedures. The following assessment battery was administered to all participants. Assessments denoted by an asterisk (*) were completed prior to the present secondary analysis of data for the current study.

MacArthur-Bates Communicative Development Inventories* (CDI: Fenson et al., 2007) were completed by caregivers of participants during data collection of the *Motor skill learning*

across toddlers with differing language skills study. The CDI are parental checklists which were used to assess participants' expressive vocabulary skills.

The Ages & Stages Questionnaire – 3rd edition* (ASQ3: Squires & Bricker, 2009) was also completed during the initial data collection. The ASQ3 is a parental checklist supplemented by direct behavioral observations, as needed, and used to assess overall developmental domains such as motor (fine and gross), communication, problem solving, and personal-social skills.

An informal parent demographic questionnaire* was completed by parents during the initial data collection (see Appendix A). This questionnaire allowed researchers to gain insight into each participant's early childhood development and background (e.g., family history, parent perspective of development, medical background, etc.).

The Khan-Lewis Phonological Analysis – 3rd edition* (KLPA-3: Khan & Lewis, 2016) was completed by researchers during initial data collection. The KLPA-3 is an assessment directly administered to each participant and was completed to identify and assess the use of speech sound production skills at the single word level. However, due to maturity levels, even though the KLPA-3 was adequately normed for use with 2-year-old children, not all the children in the study were able to complete the assessment due to attentional issues. For this reason, the following informal measures (noted below) were also included to address phonological development using utterances elicited during the KLPA-3 administration as well as from spontaneous productions in conversational exchanges with the researchers and caregiver(s) present for the initial home-based data collection visit, including individual words from multi-word utterances that were not entirely intelligible.

An informal phonetic inventory was collected from both words produced during administration of the KLPA-3 and spontaneous words produced during the data collection

sessions (see Appendix B). This tool provided an inventory of speech sounds in a participant's repertoire. The phonetic inventory identified each sound as "productive" (occuring in the beginning, middle, and end of a word production at least two times, if appropriate. For example, the /ŋ/ sound use in English does not typically occur at the beginning of words; thus, it would not be appropriate for production in this position) or "emerging" (occurring less than twice across each word position but present in at least one word production). Finally, speech sounds (also referred to as 'phonemes' of a language) were analyzed by developmental appropriateness categories of early, middle, and late developing, as noted by McLeod & Crowe (2018).

An informal word-shape analysis was completed, utilizing both words produced during administration of the KLPA-3 and spontaneous utterances produced during the data collection sessions (see Appendix C). This procedure provided insight on the complexity of syllables and syllable shapes in spontaneous and elicited utterances. Word-shape analysis allowed for further understanding of a participant's phonological production skills. Sounds in words produced were coded as consonants (C) and vowels (V) and, for each word produced, a syllable or CV "shape" was reported. Each word shape was measured by percent of use and divided into categories of monosyllabic and multisyllabic shapes. Words considered monosyllabic shape had a single vowel that may or may not be accompanied by consonants (e.g., "cat," which would be reported as a CVC shape). Multisyllabic words included at least two vowels and one or more consonants (e.g., 'kitty," which would be reported as CVCV shape), according to DeVeney and Scheffel (2019).

Data Coding Reliability. Phonetic inventory completion reliability was conducted across two participants (10% of the sample). The faculty mentor for the present study independently completed phonetic inventories for two randomly selected participants in the sample and the

results were compared with those calculated by the primary researcher. Overall, agreement of sounds produced across the two-participant sample was 89.33%. Word shape complexity reliability was also established across a two-participant sample that was randomly selected. The overall agreement on word shape identifications across the participants was 93.87%.

Data Analysis. Data analysis of the phonetic inventory and word shape complexity content included both descriptive and inferential statistics. For descriptive statistics, means, standard deviations, and ranges were computed. For inferential statistics, as a small n study with differential group sizes, the nonparametric equivalent of a t-test was used to determine the presence of meaningful correlations between language status, phonetic inventory, and word shape complexity.

Chapter III: Results

A nonparametric inferential statistic, the Mann-Whitney U test, was conducted to determine the presence of differences in phonetic inventory outcomes between the typical language or "language intact" condition group (Group 1; n=8) and those with LLE (Group 2; n=12). The total number of words produced was statistically significantly higher in Group 1 (M=81.17, SD=29.28) than Group 2 (M=48.00, SD=23.69) (p=0.016). The same test was conducted to determine the presence of differences in the total number of singleton consonants emerging across all word positions, total number of singleton initial productive sounds, total number of singleton final productive sounds, and total number of clusters (productive and emerging) across all positions between condition groups. The total number of singleton consonants emerging across all word positions was statistically significantly higher in Group 1 (M=13.75, SD=3.75) than Group 2 (M=12.75, SD=4.06) (p=0.025). The total number of singleton initial productive sounds was statistically significantly higher in Group 1 (M=12.00,

SD=2.89) than Group 2 (*M*=8.25, *SD*=3.85) (*p*=0.020). The total number of singleton final productive sounds was also statistically significantly higher in Group 1 (*M*=8.91, *SD*=3.80) than Group 2 (*M*=6.75, *SD*=3.25) (*p*=0.007). Further, the total number of consonant clusters (productive and emerging) across all positions was significantly statistically higher in Group 1 (*M*=9.42, *SD*=7.37) than Group 2 (*M*=1.38, *SD*=1.41) (*p*=0.012).

A Mann-Whitney U test was conducted to determine the presence of differences in word shape complexity between the two condition groups. The total number of word shapes used was statistically significantly higher in Group 1 (*M*=15.67, *SD*=6.11) than in Group 2 (*M*=9.50, *SD*=3.34) (*p*=0.012). The total number of multisyllabic productions was statistically significantly higher in Group 1 (*M*=9.67, *SD*=4.31) than in Group 2 (*M*=4.88, *SD*=2.59) (*p*=0.020). The total number of monosyllabic productions was not statistically significant between Group 1 (*M*=6.00, *SD*=2.30) and Group 2 (*M*=4.50, *SD*=1.77) (*p*=0.157).

Chapter IV: Discussion

The findings from the present study supported those of previous research conducted with smaller participant samples. For example, Schwartz and colleagues (1990) conducted a study with six participants, ages 1 year, 7 months to 3 years, 7 months. Three participants had language delay and three children were noted to have typical language development. These children were compared according to multiple speech-language skills, including phonological productions. The researchers found that the two groups showed similarities between younger children with language that was typically developing and those with language delay, demonstrating a delayed, rather than disordered, development of consonant classes for young children presenting with language delay.

The current findings also aligned with the findings of Williams and Elbert (2003), who conducted a longitudinal study over one year with five participants identified as having LLE. Over the course of the study, three children demonstrated typical language abilities by the age of three. The remaining two children continued to demonstrate differences in syllable shape structures and phonological patterns. The findings of this study suggest that late-talking toddlers with disordered phonological productions have more persistent language difficulties through early childhood than children with delayed phonological skills. As such, children identified as having LLE have variable phonological abilities, as demonstrated by findings of the current study, and will likely have variable language development and outcomes over time.

In a study conducted by Mirak & Rescorla (2008), 37 toddlers with LLE and 20 peers who had typical language development were compared based on phonological productions and vocabulary size. Children with LLE produced around one-third the number of consonants when compared to their peers. Although, consonants that were frequently used across both groups were similar, indicating a delay rather than disordered language development. The number of consonant types produced was also correlated to vocabulary size. These findings align with the current study's findings of the correlation between vocabulary size and productive consonant sounds produced when comparing participants identified with LLE and those with language that was typically developing, as measured by informal language sampling and informal phonetic inventory.

Limitations. As a small n study with few participants identified with LLE, generalizability of the findings is limited. Variability in participant utterances also presented a limitation with the current study, as robustness of language samples differed across participants. Further, the research focus on two informal measures of speech sound productions, phonetic inventory and

word shape analysis, was out of necessity as many early participants in the study were unable to complete the KLPA-3 in its entirety. Ideally, standardized assessments would also be utilized for determining study outcomes.

Future directions. For the ongoing study, *Motor skill learning across toddlers with differing language skills,* a cross-linguistic comparison with Hebrew-only speaking participants (n=35) is planned to determine the universality of the neural underpinnings of language, motor, and speech sound production development and their connection, regardless of primary language. The Hebrew sample also includes children identified with LLE and allows for further analysis of speech sound productions, word shape complexities, motor aspects, and overall language capabilities of children from a more global perspective.

Further, analysis of additional speech sound production data may be conducted beyond the current informal tools utilized to analyze phonological and word-shape complexity aspects of language. For instance, for inclusion of standardized normative comparisons across study participants, a new assessment tool specifically designed for determining speech sound production in the toddler population will soon be available for clinical and research use. This assessment tool, the *Profiles of Early Expressive Phonological Skills* (PEEPS) (Williams & Stoel-Gammon, in press) was designed for specific use with young children between the ages of 18 to 36 months of age. Use of a phonological assessment tool specifically focused on this age group may help to facilitate completion of a standardized measure of speech sound production that can then be analyzed and compared with same-aged peers.

Clinical implications. The correlation between phonological productions and language abilities of toddlers has been identified across multiple studies. The current study further supported the notion that young children with language delays often present with fewer productive sounds

across positions in words. Young children with language delay often present with less complex syllable structure than their peers with typical language development. It is important for clinicians to be mindful of the likelihood that both language and speech sound production skills may be delayed in children with LLE and both areas may warrant assessment and early intervention.

Conclusion. The present study was a secondary analysis of data collected from 20 two-year-old children, 8 of whom presented with LLE. The participants were divided into two attributional condition groups, one with language intact (Group 1) and one with LLE (Group 2). To determine differences in speech sound production skills, the phonetic inventory and word shape complexity measurements were compared across the two groups. Present study findings indicated statistically significant differences across language proficiency groups, such that the 'language intact' group were observed to have substantially more speech sounds (phonemes) in their sound production repositories and also were observed to produce more complex word shapes than the LLE group. Findings from the present study align with previous literature regarding the correlation between language status and phonological productions. Such that, the more phonemes in a child's repertoire, the more likely they will be to fall under the category of "language intact" (Fisher, 2017; Williams & Elbert, 2003; Zubrick et al., 2007). Further, the present study aligned with previous literature regarding the correlation between language status and word shape complexity productions. The more complex word shapes utilized, the more likely the child will fall under the category of "language intact" (Pharr et al., 2000; Zubrick et al., 2007). The clinical implications of these findings indicate the need for clinicians to be mindful of both speech and language deficits in young children, as both may necessitate assessment and

intervention at an early age and are both likely to be observed in children with suspected LLE. Further investigation to better characterize the nature and extent of this relationship is warranted.

References

Bishop, et al. (2016). A multinational and multidisciplinary delphi consensus study: Identifying language impairments in children. *Plos One, 11*(12) https://doi.org/10.1371/journal.pone.0168066

DeVeney, S. & Scheffel, L. (2019). Connected speech of two-year-olds: Test-retest reliability for assessment of phonetic inventory and word shape analysis. *Clinical Archives of Communication Disorders, 4*(3), 1-14. https://doi.org/10.21849/cacd.2019.00143

DeVeney, S., & Sheridan, K. (2017). Short-term stability of phonological measures in a sample of two-year-old late talkers. *Clinical Archives of Communication Disorders, 2*(3), 227-237. https://doi.org/10.21849/cacd.2017.00206

Fenson, L. et al. (2007). McArthur-Bates Communication Development Inventory (MB-CDI): Technical Manual.

Fisher, E.L. (2017). A systematic review and meta-analysis of predictors of expressive-language outcomes among late talkers. *Journal of Speech, Language, and Hearing Research, 60*(10), 2935-2948. https://doi.org/10.1044/2017_JSLHR-L-16-0310

Gendler-Shalev, H., Ben-David, A., & Novogrodsky, R. (2021). The effect of phonological complexity on the order in which words are acquired in early childhood. *First Language, 41*(6), 779-793. https://doi.org/10.1177/01427237211042997

Gray, K. & Tongue (2005). Developmental Behavioral Checklist: Early Screen (DBC-ES): Technical Manual.

Khan, L. & Lewis, N.P. (2015). Khan-Lewis Phonological Assessment, 3rd Edition. (KLPA-3). *Pearson Publishing.*

Krishnan, et al. (2016). Neurobiological basis of language learning difficulties. *Trends in Cognitive Science, 20*(9), 701-714. https://doi.org/10.1016/j.tics.2016.06.012

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

Mirak, J. & Rescorla, L. (2008). Phonetic skills and vocabulary size in late talkers: Concurrent and predictive relationships. *Journal of Applied Psycholinguistics, 19*(1), 1-17. https://doi.org/10.1017/S0142716400010559

Pharr, A.B., Ratner, N.B., & Rescorla, L. (2000). Syllable structure development of toddlers with expressive specific language impairment. *Psychology Faculty Research and Scholarship, Bryn Mawr College, 21*(4), 429-449. https://doi.org/10.1017/S014271640000401

Schwartz, et al., (1990). Early phonological behavior in normal-speaking and language disordered children. *Journal of Speech and Hearing Disorders*, *45*(3), 357-377. https://doi.org/10.1044/jshd.4503.357

Squires, J., & Bricker, D. (2009). *Ages & Stages Questionnaires®, Third Edition (ASQ®-3): A Parent-Completed Child Monitoring System*. Brookes Publishing.

Stoel-Gammon, C. (1987). Phonological skills of 2-year-olds. *Language, Speech, and Hearing Services in Schools, 18*(4), 323-329. https://doi.org/10.1044/0161-1461.1804.323

Ullman, M.T. & Pierpont, E.I. (2005). Specific language impairment is not specific to language: The procedural deficit hypothesis. *Elsevier Cortex, 3*(41), 339-433. https://doi.org/10.1016/S0010-9452(08)70276-4

Williams, A.L. & Elbert, M. (2003). A prospective longitudinal study of phonological development in late talkers. *Language, Speech, and Hearing Services in Schools, 2*(34), 138-153. https://doi.org/10.1044/0161-1461(2003/012)

Zubrick, S.R., Taylor, C.L., & Rice, M.L. (2007). Late language emergence at 25 months: An

epidemiological study of prevalence, predictors, and covariates. *Journal of Speech, Language, and Hearing Research, 50*(6), 1562-1592. https://doi.org/10.1044/1092-4388(2007/106)

Appendix

A: Demographic questionnaire

Parent Demographic Questionnaire
Questions 1-9 administered verbally by research personnel. Referred to below as 'interviewer.'
Question 10-14 filled out by parent.

Participant ID:
Child's DOB:
Research Personnel ID:
Relationship (to child) of Interviewee (mother, father, grandparent, etc.): _____

_____
_____ (month/date/year) Chronological Age: _____ (in mths) _____ Current zip code: _____

1. What is the primary language spoken in your home? _____

2. Are there other languages spoken in your home? _____

3. Does your child speak only one language? Y/N What language? _____

4. Describe your child's birth history.
• Tell me about your child's prenatal history. Any complications during the pregnancy?

• If so, please describe.

- What was your child's weight at birth? _____ (lbs)
- Was your child born prematurely? Y / N
  - If yes, how many weeks? _____
- Were there any complications during labor? Y / N

• If so, please describe.

- What was the mother's age at time of the child's birth? _____
- Were you pregnant with multiples?

5. Describe your child's general developmental history.
• Has your child ever been hospitalized or had surgery? Y / N

▪ If so, please describe.

• Does your child have any medical diagnoses or allergies? Y / N ▪ If so, please describe.
- Participants diagnosed with autism spectrum disorder or other neurological, physical, or sensory impairments.

5.1 Are there other children currently living in the home? Y / N

- How many?
- What are their ages and relationship to the child?
- Where is the child in the birth order sequence (e.g., first born, second, etc.)?

5.2 Does your child have first degree male or female relatives who were diagnosed with any developmental delay? If so, what? (Interviewer prompt: When I say 'first degree' I mean brother or a sister or parent with developmental delay) Y / N

▪ If so, please describe.

5.3 What is the family composite? Please choose from one of the following:
- Two-parent
- Single parent
- Other: _____

5.4 Is your child in group care? If so, of what type (e.g., private, public, in-home daycare). For how many hours per week? (e.g., below 10 hours, partial, between 10-30, over 30 hours or full time)

6. Are there any family circumstances you feel we should know about (Interviewer prompt: For example, new baby in the family, a divorce, a separation, or a recent death in the family)? Y / N
- If so, please describe.

7. Do you have any concerns about your child's development? Y / N

• If so, please describe.

8. How many hours a day do you estimate that your child engages in sports/motor activity?
_____

9. How many hours a day do you estimate that your child plays with puzzles, legos, or building games? _____

10. Does your child attend daycare? Y/ N If so, for how many hours a day? How many days a week? _____

11. What is your current occupation?

12. What is your partner's current occupation? *(Omit for single parents)*

The following information is optional.Complete questions 10-14, as you feel comfortable.

13. Which race/ethnicity group do you identify with? Please choose from the following:
    1. African American
    2. Caucasian
    3. Latino
    4. Native American
    5. Asian
    6. Other: _____

14. Which race/ethnicity group does your child identify with? Please choose from the following:

    1. African American
    2. Caucasian
    3. Latino
    4. Native American
    5. Asian
    6. Other: _____

15. What is the first language of the parent (a.k.a. Parent mother tongue):
    _____

16. What your highest level of education? Please choose from the following:

    1. Less than HS
    2. HS/GED
    3. Some College
    4. 4-year college completion
    5. Post-graduate

17. What your partner's highest level of education? Please choose from the following: *(Omit for single parents)*

1. Less than HS
2. HS/GED
3. Associative degree/professional diploma/community college (1-2 year program)
4. Some university
5. 4-year university completion
6. Post-graduate

18. The average income per family in the United States is $59,039. How does your household income compare? Please choose from the following:

1. Much below
2. Somewhat below
3. The same as national average
4. Somewhat above
5. Much above

19. How many occupants currently live in your home? _____

B: Informal Phonetic Inventory data sheet

Phonetic Inventory

Name: _____ Age: ____ Source of Speech Sample: _____

Examiner: _____ Number of Words: _____ Date: _____

	Syllable Position		
Manner of Production	**Initial**	**Intervocalic**	**Final**
Stop p b t d k g			
Nasal m n ŋ			
Fricative f v s z ʃ ʒ θ ð h			
Affricate ʧ ʤ			
Glide j w			
Liquid l r			
Consonant Cluster			

Includes unintelligible utterances? ☐ Yes ☐ No

Comments:

C: Informal word shape complexity tally sheet

Participant:			
Date Completed:			
Word Shapes Observed			
Shape:	Tally # of each		% of use
V			
CV			
VC			
CVV			
CVC			
VCV			
CCV			
VCC			
CVCC			
VCVC			
CVCV			
CCVV			
CCVC			
CVVC			
CVCC			
VCVCV			
CVCVC			
CVCCV			
CCVCV			
VCVCVC			
VCVCC			
CVCVV			
CVCVCV			
CCVCC			
CCVCVC			
VVCVCC			
CVCCVC			
CVCCVCC			
CCVCCVC			
CVCVCVC			
CVCCVCV			
CVCCVCVC			
CCVVCCVC			
VCCCCVCVCC			
Total Words			