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The Role of Word Form in Lexical Selection of Late Talkers

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ABSTRACT

Purpose: The lexical selection hypothesis posits that first words added to a toddler's spoken vocabulary will be predominantly those beginning with early developing consonant phonemes. Using this framework, we evaluated the relationship between word form and lexical selection among late talkers and two typical comparison groups.
Method: An online database of MacArthur–Bates Communicative Developmental Inventories was used to extract the American English Words and Sentences Form (MB-CDI:WS). Inventories were divided into three groups: (a) a late talkers group (LTs; n = 202), (b) a typically developing age-matched group (TDA; n = 1,238), and (c) a younger, typically developing language-matched group (TDL; n = 196) matched on expressive language to the LTs. The first phoneme in each word produced by every toddler on the MB-CDI:WS was coded as early, middle, or late developing. The proportion of spoken words starting with phonemes in each developmental category was calculated. Mixed-effects models were used to evaluate group differences.
Results: All three groups' spoken vocabularies consisted mostly of words beginning with early developing phonemes. LTs and TDLs used more words beginning with early developing consonants than TDAs. TDAs had a higher proportion of words starting with middle- and late- developing phonemes than LTs and TDL groups. The LTs group produced a significantly smaller proportion of words beginning with middle-developing phonemes compared to the TDL group.
Conclusions: Initial phonemes produced in the lexicons of LTs are, in general, similar to both language-matched and age-matched typical toddlers and reflect lexical selection. Clinical implications of these findings will be discussed.

Unlike other primates, who are born with their full complement of vocalizations from birth (Oller et al., 2016), human infants have a unique capacity for acquiring vocal productions that are shaped through exposure to their linguistic environment (Curtis et al., 2023). Biological changes to the vocal tract (Vihman et al., 1986) along with the development of volitional motor control and imitation abilities (Ekström, 2022) work synergistically to support the acquisition of the phonological system during early development.

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Phonological Development

The phonological system has two broad components, perception and production, where production provides feedback to strengthen perception (Choi et al., 2023). The perceptual element of the phonological system includes the storage and categorization of acoustic information that represents phonemes in memory. These mental representations of sound categories, or phonemes, are established and refined over the first year of life as a result of linguistic input (Werker & Tees, 1984) and predict later spoken language milestones including the onset of first words (Tsao et al., 2004). By about 9 months of age, most infants have undergone the process of perceptual narrowing and are no longer sensitive to nonnative phonetic contrasts suggesting their ambient language environment has shaped their perceptual system (Tsao et al., 2004).

Protophones (e.g., vowel-like vocalizations) and spoken phonemes provide the foundation for an expressive lexicon (Oller et al., 2021). A spoken consonant inventory begins with the manifestation of canonical babbling and the earliest developing phonemes are generally those that require simple motor patterns and can be produced with relative ease by the infant (Aoyama & Davis, 2017). Cross-linguistic studies of infant vocal behavior highlight likenesses in the acquisition patterns of phonemes across languages (Edwards & Beckman, 2008), suggesting that the system is strongly influenced by the universal similarities in the vocal tract and motor development across human infants. For example, bilabials /m/, /p/, /b/ are some of the earliest produced phonemes in English, French, and K'iche' (Ingram & Babatsouli, 2024), requiring relatively simple motor movements (Aoyama & Davis, 2017). As the motor system develops, the perceptual system shapes spoken phonological inventories and a differentiation in phonemic production is observed specific to the language in which the young child is exposed. The sequence of phonological acquisition in typically developing (TD) English-exposed toddlers is well documented (Crowe & McLeod, 2020) with consonantal phonemes often described in order of mastery from early (stops, nasals, glides), to middle (some fricatives and affricates) to late (interdentals, liquids, and glides; Crowe & McLeod, 2020; Shriberg, 1993; see Table 1). Importantly, the production of phonemes stabilizes and strengthens phonological representations in memory; thus, infants and toddlers who produce low levels of babble may be at risk for weaker underlying phonological representations as they do not benefit from the practice effects afforded to TD infants and toddlers (Gershkoff-Stowe & Hahn, 2007).

Phonology and LTs

LTs are generally described as toddlers between 18 and 35 months of age with small expressive vocabularies in the absence of any frank neurological impairments, sensory deficits, or neurodevelopmental disabilities (Paul, 1991; Paul & Jennings, 1992; Rescorla, 1989). Approximately 15% of toddlers meet criteria for late talking (Collisson et al., 2016), which has the potential for long term sequalae on social–emotional well-being, along with academic and vocational achievement (Singleton, 2018).

Much of the literature describing the symptom expression of LTs has focused on their limited spoken vocabulary size as it represents the primary symptom and is most noticeable by parents. A secondary symptom of this group is atypical expressive phonology where differences between LTs and TD peers emerge relative to the timing of phonological milestones, volubility of vocalizations, and complexity of phonological forms produced (Paul, 1993; Paul & Jennings, 1992; Rescorla & Ratner, 1996; Thal et al., 1995). Delayed onset of canonical babbling (i.e., no reduplicated sequences such as *bababa* by 10 months of age; Oller et al., 1999), babble limited to only vowels (Whitehurst et al., 1991), and less frequent vocalizing (i.e., lower volubility; Thal et al., 1995) have been reported in toddlers with small vocabularies. Once LTs begin to produce first words, their word forms contain both fewer consonant types (Rescorla & Ratner, 1996) and less complex syllable structures compared to same-age peers (Paul & Jennings, 1992). This literature points to limited expressive phonology as one possible contributing factor in late talking while also highlighting the relationship between phonological production and lexical development (Stoel-Gammon, 1998).

The Role of Phonology in Lexical Selection

The first words produced by toddlers often contain the same phonemes produced in babbled, prelinguistic vocalizations (Oller et al., 1976), supporting the transformation of vocal play into meaningful production. For example, the canonical babble production *mama* may move from vocal play to meaningful use around the toddler's first birthday as a label for their mother. The first 50 words expressed by toddlers generally contain the early phonemes and resemble syllable shapes produced prelinguistically in babble and these phonemes and syllable shapes form the building blocks for early words (Stoel-Gammon, 2011). Longitudinal studies that tracked infants from prelinguistic babble to first words found that those infants who had more diverse prelinguistic phonological production inventories had larger spoken lexicons as toddlers (Keren-Portnoy et al., 2009; Stoel-Gammon, 1989).

Table 1. Phonemic consonant categories by order of development.

Developmental level	Shriberg (1993)	Crowe and McLeod (2020)
Early	/m/, /b/, /j/, /n/, /w/, /d/, /p/, /h/	/m/, /b/, /j/, /n/, /w/, /d/, /p/, /h/, **/t/**, **/ŋ/**, **/k/**, **/g/**, **/f/**
Middle	**/t/, /ŋ/, /k/, /g/, /f/,** /v/, /tʃ/, /dʒ/	/s/, /l/, /ʃ/, /z/, /v/, /ʧ/, /ʤ/
Late	/s/, /l/, /ʃ/, /z/, /θ/, /ð/, /ɹ/, /ʒ/	/θ/, /ð/, /ɹ/, /ʒ/

Note. International phonetic alphabet notation used. Bolded items represent phonemes classified by Shriberg (1993) as Middle and classified by Crowe and McLeod (2020) as Early. Italicized items represent phonemes classified by Shriberg (1993) as Late and classified by Crowe and McLeod as Middle.

A relatively large body of research supports the notion, first proposed by Ferguson and Farwell (1975), that early words are selected for production, in part, on the basis of their phonological content. Many studies on a range of languages, using a variety of methods including experimental word-learning paradigms, language sampling, and parent report, converge on the finding that sound properties of words influence lexical production (Fletcher et al., 2004; Gayraud & Kern, 2007; Gendler-Shalev et al., 2021; Kehoe et al., 2020; Macken & Ferguson, 1983; Schwartz & Leonard, 1982; Stoel-Gammon, 1998; Stoel-Gammon & Cooper, 1984; Viterbori et al., 2018). This implicit bias, known as "lexical selection," is evidenced by the preponderance of words containing primarily initial consonants that are in-repertoire within toddlers' phonological inventories, while other consonants in the word may undergo substitution or deletion. Although not the only factor influencing early selection of words for production (Hodges et al., 2017; Kehoe et al., 2020), this kind of phonological preference is thought to arise from toddlers' tendency to say, from all words in their receptive lexicon, those that have at least beginning phonemes they can already articulate. Parent report measures of vocabulary production are one of the means that have been used to support this finding, which is generally interpreted to reflect a process of implicit lexical selection based on phonological form. Davis et al. (2018) showed that the effect of this selection was strongest for phonemes in initial word position.

Present Study

Our study aims to determine whether LTs make use of lexical selection as their language-typical peers appear to do. To accomplish this, we coded the first phoneme of each word produced on a standardized parent checklist of spoken vocabulary in three groups of toddlers: those who scored at or below the 15th percentile (LTs), an age-matched group with productive lexicon scores within the typical range, and a younger group of toddlers matched to the LTs for expressive vocabulary size. The language-matched group will be used to determine if the lexical selection pattern of LTs is similar to that of younger, expressive language matched toddlers. We predict that the LTs will use lexical section in a manner more similar to language-matched peers reflecting a delay and not an atypical pattern of adding words to their expressive vocabulary relative to phonology.

Method

Data Acquisition and Reduction

Wordbank (Frank et al., 2016) is an online, open-source database of MacArthur–Bates Communicative Developmental Inventories (MB-CDI, Fenson et al., 2007), a group of norm-referenced parental reports of infant and toddler communication and language skills. Given the nature of the open-source anonymized database, this study was exempt from the institutional review board process. Using Wordbank, 1,636 Words and Sentences Forms (MB-CDI:WS) were obtained. The Words and Sentences form provides a robust, standardized measure of spoken vocabulary size for toddlers 16–30 months. This form provides the caregiver with a list of 680 possible items that are organized by semantic and syntactic categories (e.g., actions, toys, foods, prepositions) and the caregiver selects which words the toddler produces regularly. We constrained our inclusion to the American English Form as the focus of this article was American English phonology.

Any word beginning with a vowel was eliminated (n = 66), as we were interested in the consonant phonemes that form the basis for many early words (MacNeilage & Davis, 2000). Of the remaining 614 items, we subsequently removed an additional 48 items including nonword sound effects (e.g., "shh," "moo"; n = 10), two-word phrases (e.g., "green beans," "next to"; n = 13), proper nouns (e.g., pet's name, babysitter's name; n = 8), routines (e.g., "give me five," "this little piggy"; n = 9), and catenatives ("gonna," "lemme"; n = 8). The motivation for eliminating these were twofold: (a) Some items were idiosyncratic to the participant (e.g., pet's name) or (b) might be simplified by the family and might affect the phonology of the word (e.g., the "green beans" item may be referred to as "beans"). Most items eliminated were multisyllabic words, which only represent a small proportion of the developing toddler lexicon while preserving monosyllabic forms that comprise the bulk of their early spoken words (Gendler-Shalev et al., 2021). A possible 566 words remained for analysis including noun, verb, adverb, adjective, preposition, social (e.g., "hi," "bye"), and function (e.g., "yes," "no") word classes.

Inventory Groups

MB-CDI:WS participant forms were separated into three groups based on chronological age and expressive vocabulary percentile rank. The LTs group (n = 202) included toddlers aged 21–30 months who scored at or below the 15th percentile on the MB-CDI:WS, consistent with age ranges and cutoff scores used to describe LTs (Collisson et al., 2016; Curtis et al., 2023; Ellis et al., 2015; Ellis Weismer et al., 2011; Horvath et al., 2019; MacRoy-Higgins et al., 2013, 2016). The two comparison groups included a TD group (n = 1,238) who were matched on chronological age (TDA) to the LTs and a language-matched group (TDL; n = 196) who were

matched to the LTs on the number of spoken words produced on the MB-CDI:WS. The TDL participants were younger than both the LTs and TDA groups and ranged from 16 to 17 months of age. Matching procedures used for the TDL group aligned with the limited number of studies that include an expressive language-matched group (MacRoy-Higgins et al., 2013; Thal et al., 1995). Both TD groups had spoken vocabularies at or above the 30th percentile for their age (Sosa & Stoel-Gammon, 2012).

Groups were well matched on chronological age, expressive language levels, and biological sex. Pairwise comparisons revealed no significant differences between the LTs and the TDA groups on chronological age or between the LTs and the TDL groups on mean number of words produced on the MB-CDI:WS. Chi-square tests showed no differences in the proportion of males across the three groups. Although maternal education level across all three groups consisted mostly of some college or additional education, mothers from the LTs group had lower levels of education compared to the TD groups (see Table 2 for details).

Data Coding

The first phoneme in each word produced on the MB-CDI:WS by each toddler, not inclusive of words with vowel initial phonemes, was coded as early, middle, or late developing, using Shriberg's (1993) consonant categories (see Table 1). The decision to use Shriberg's system, rather than the more recent taxonomy provided by Crowe and McLeod (2020) has two sources. First, the order of acquisition of phonemes in both systems is the same (see Table 1). The difference arises during the parsing of phonemes into developmental levels. Crowe and McLeod considered any phonemes acquired before 4 years of age to be early developing. This is a very sensible approach for a classification system aimed to help determine which preschoolers are in greatest need of articulation intervention. Four-year-olds still missing any early phonemes would indeed be classified as delayed and would benefit from intervention. However, when studying toddlers with both typical and delayed language development, the Shriberg system provides a more granular classification. None of the participants in our sample was older than 30 months. Crowe and McLeod classified all consonants acquired by 47 months of age as "early developing," over a year beyond the developmental level of our participants. Therefore, separating out what might be called the "later early" consonants (/t, ŋ, k, g, f/)—none of which is acquired according to Crowe and McLeod's data (pp. 2161) until after 36 months—into "middle developing," as Shriberg does, seems a more valid classification scheme for evaluating phonological performance in toddlers 30 months and younger. Similarly, none of the four consonants considered as "late developing" by Shriberg and in the middle developing (/s, l, ʃ, z/) by Crowe and McLeod is acquired before 50 months in Crowe and McLeod's report, leading us to surmise that, like the four phonemes classified as late developing by Crowe and McLeod, they will be relatively rare in both late talking and TD toddlers. Thus, Shriberg's system better aligned to the phonological repertoires of our toddler participants.

Our second rationale for using Shriberg's (1993) system lay in the equal numbers of phonemes in his three groups. By limiting the phonemes considered early to the eight that appear before 36 months in typical development,

Table 2. Demographics and expressive vocabulary by group.

	Group			One-way ANOVA		*p* values from pairwise comparisons or χ^2		
	TDA (*n* = 1,238)	TDL (*n* = 196)	LTs (*n* = 202)	*F*	*p*	TDA vs. TDL	TDA vs. LTs	TDL vs. LTs
Mean chronological age in months (*SD*)	25.75 (2.50)	16.43 (0.49)	25.55 (2.33)	1,369.00	< .001	< .001	.50	< .001
Age range in months	22–30	16–17	22–30	-	-	-	-	-
Percent male	51%	49%	53%	-	-	.76	.54	.49
% with maternal education ≥ some college	81%	86%	69%	-	-	< .001	< .001	< .001
Mean MB-CDI:WS Percentile (*SD*)	66% (20%)	60% (20%)	8% (4%)	791.40	< .001	< .001	< .001	< .001
Mean # of words produced on MB-CDI:WS (*SD*)	453 (140)	103 (84)	92 (68)	1,176.00	< .001	< .001	< .001	.66

Note. Numbers in parentheses are standard deviations. MacArthur–Bates Communicative Developmental Inventories: Words and Sentences Form (MB-CDI:WS; Fenson et al., 2007). ANOVA = analysis of variance; TDA = typically developing age-matched; TDL = typically developing language-matched; LTs = late talkers.

and considering those typically mastered at 36–48 months to be in the middle-developing group, there was an improved chance of observing a difference between the very first and the somewhat later sounds, which would provide a more realistic picture of the phonological limitations of the late-talking toddlers. Supplemental Material S1 provides a table for each word included in analysis, its phoneme category (Shriberg, 1993), and age of acquisition (see Table 1).

The total number of words produced from each phonological category (Shriberg, 1993) was summed. The proportion of spoken words beginning with our early, middle-, and late-developing consonant phonemes was calculated for every toddler (number of words produced from each consonant category/total number of words produced with a consonant in word-initial position).

Analysis Plan

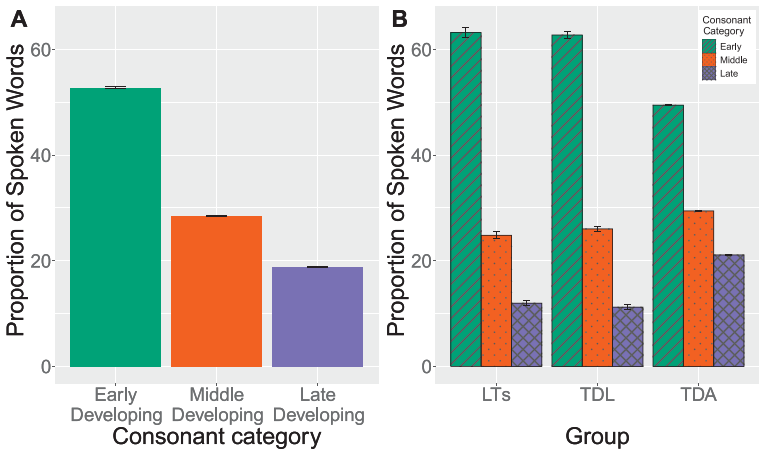
Analyses were conducted in R (R Core Team, 2020) using the *afex* package (Singmann et al., 2018) and the *aov_4* function for mixed-effects models. The *emmeans* package was used for planned post hoc comparisons (Lenth et al., 2020). Group (LTs, TDL, and TDA) and Consonant Category (early developing, middle developing, and late developing) were used as the fixed factors. The dependent variable was proportion of words with word-initial consonants from each consonant category. The Group × Consonant Category interaction was also computed and was our variable of interest. Participant was included as the random effect (intercepts) as the model failed to converge when random slopes were added (Barr et al., 2013).

Results

There was no main effect of Group ($F < .001$; $p > .99$), but there was a significant main effect of Consonant Category ($F = 1{,}275.19$; $p < .001$) on proportion of words produced. The absence of Group main effect indicates the proportion of words produced from each consonant category summed to 100% for each participant in each group which was predicted given the formula used to calculate proportions. Holm-adjusted post hoc comparisons revealed, collapsed across groups, participants were generally producing a greater proportion of words beginning with early developing ($t = 149.82$, $p < .001$) phonemes compared to middle-developing ($t = -39.16$, $p < .001$) or late-developing ($t = -110.66$, $p < .001$) phonemes (see Figure 1a).

The interaction of Group x Consonant Category was our variable of interest and was also significant ($F = 623.30$; $p < .001$; see Figure 1b). Again, Holm-adjusted post hoc comparisons revealed that a greater proportion of words produced by both the LTs and TDL groups began with early developing consonants, compared to the TDA group. The inverse pattern was observed for the middle- and late-developing consonant categories. For these categories, the TDA group produced a greater proportion of words from the middle- and late-developing consonant categories compared to both the LTs and TDL groups. Significant differences were also observed between

Figure 1. Bar plots of mean proportion of spoken words by (a) developmental consonant category and (b) diagnostic group. (a) Mean proportion of spoken words from the MacArthur–Bates Communicative Developmental Inventories: Words and Sentences Form (MB-CDI:WS; Fenson et al., 2007) beginning with early, middle-, or late-developing consonants collapsed across diagnostic groups (Shriberg, 1993). (b) Mean proportion of spoken words from the MB-CDI:WS beginning with early, middle-, or late-developing consonants by diagnostic group. Error bars represent standard error for both plots. LTs = late talkers; TDL = typically developing language-matched; TDA = typically developing age-matched.



the LTs and TDL groups for words beginning with middle-developing phonemes. The TDL group produced a significantly greater proportion of words starting with middle-developing consonants compared to the LTs group (see Table 3 for post hoc comparisons).

Discussion

The aim of this study was to determine whether the early spoken lexicons of late-talking toddlers showed a bias toward words beginning with early developing consonants, as suggested by the lexical selection account. This account predicts that very young children are more likely to produce words in the early stages of lexical acquisition that contain phonemes already within their phonological repertoire particularly in initial position. We found that late-talking toddlers' first words generally do appear to follow a pattern like that of typical peers, at least as measured by a preference for early developing phonemes in initial word position, suggesting use of lexical selection. We found, further, that both the LTs and TDs' expressive vocabularies are, in accord with other research reported for typical toddlers (Davis et al., 2018; Gendler-Shalev et al., 2021), composed primarily of words beginning with early developing phonemes. Our data also show that words with middle-developing phonemes were produced next most often, and late-developing phonemes represented the smallest proportion words in early spoken vocabularies by all three groups. We have provided a scatter plot showing the relationship between phoneme category and spoken vocabulary size in Supplemental Material S2 as another way to visualize the results (Figure 1).

Although the general order of proportions among word forms is similar across the three groups (words with early developing phonemes in initial position > words with middle-developing phonemes in initial position > words with late-developing phonemes in initial position), LTs appear to produce a marginally smaller proportion of words starting with middle-developing consonants compared to their language-matched peers ($p < .04$). This finding could represent a statistical artifact, influenced by the large difference in standard deviation of values for proportion of words beginning with middle-developing phonemes for the two groups. Alternatively, it could be a valid reflection of an increased constraint on acquisition of more advanced, middle-developing phonemes for LTs. This interpretation seems less likely, given that, although a nonsignificant difference, the proportion of words beginning with late-developing phonemes produced by LTs is slightly larger than by the TDL group. A clear interpretation of this finding awaits replication of these results with other samples or use of more direct sampling methods rather than parent report.

These findings do generally align with previous work (Paul, 1993; Paul & Jennings, 1992; Rescorla & Ratner, 1996; Thal et al., 1995), which demonstrates that phonological development in LTs appears to have some relation to slow expressive vocabulary growth. This earlier work using direct sampling of vocal and verbal production of LTs revealed limited phonological repertoires. The present study, which examines early lexical production by means of parent report can be interpreted to validate the earlier findings, showing that LTs are more likely to say words with early developing initial consonants than are typical age mates. The older, language typical toddlers in this sample appear to have a broader range of spoken phonemes at their disposal, allowing, proportionally, more words beginning with middle- and late-developing phonemes that support the addition of more variable word forms.

A range of contributors to order of acquisition of early words have been suggested, including frequency of linguistic input, phonological neighborhood density, statistical learning, social cueing, and syntactic bootstrapping (Braginsky et al., 2019; Hodges et al., 2017; Jones & Brandt, 2019; Kehoe et al., 2020; Tomasello, 2000). It seems likely that phonological accessibility of the phonemes and the structure of early words is an additional contribution. Future longitudinal research that examines the relations between perceptual knowledge, measured perhaps by eye tracking, and

Table 3. Post hoc comparisons of Group × Consonant Category Interaction.

	Pairwise comparisons								
	LTs vs. TDL			LTs vs. TDA			TDL vs. TDA		
Consonant category	**EMM***	***t***	***p*******	**EMM**	***t***	***p*******	**EMM**	***t***	***p*******
Early developing	0.46	0.96	.33	13.75	37.52	< .001	13.29	35.79	< .001
Middle developing	–1.22	–2.51	.04	–4.61	–12.59	< .001	–3.40	–9.15	< .001
Late developing	0.75	1.55	.24	–9.14	–24.94	< .001	–9.89	–26.64	< .001

Note. LTs = late talkers; TDL = typically developing language-matched; TDA = typically developing age-matched.

*EMM = estimated marginal means using Holm-correction for multiple comparisons. **p value corrected for multiple comparisons.

expressive skills in these populations could serve to provide a deeper understanding of the course of word learning.

Limitations

A major limitation of data on speech production drawn from parent report checklist is, of course, that the parent does not report how the child pronounced the word, only that it was said by the toddler and recognized by listeners. Perhaps the toddler has a recognizable approximation for "shoe," but actually say /du/. In our coding system, the toddler would receive credit for a late sound /ʃ/, even though an earlier sound was produced.

The MB-CDI:WS has been used to understand the relationship between spoken phonology and lexical development in previous work as the features of words included on this instrument match closely to direct observations of toddler spoken phonology (Stoel-Gammon, 1998). Moreover, recent research has employed WordBank data, just as we have, to examine the properties of toddlers' early lexicons (Braginsky et al., 2019; Davis et al., 2018; Gendler-Shalev et al., 2021; Horvath et al., 2022). Although we acknowledge that using the MB-CDI:WS in a study of phonological issues would fail to capture pronunciation errors in situations such as the example above, when a target word is recognizable by adults, our contention is the lexical selection bias draws on the underlying phonological representation of the word. This mental representation would serve as the basis for selection and production. Even if the production itself is an approximation, we would argue that toddlers are more likely to attempt sounds for which they have an available motor plan, even if the plan is not a perfect one, derived from frequent practice in babbling and early speech than to attempt phonemes for which the underlying phonological representation and motor plan are less fully developed. The fact that findings from studies using artificial language learning, language sampling, and parent report converge strengthens the assertion that parent report is a relatively valid means of assessing lexical selection.

An additional potential limitation is the way in which we chose to create our proportions. Indeed, there are a greater number of words in the early developing category (~49% of words analyzed) compared to the middle-developing (23% of words analyzed) and late-developing (28% of words analyzed) categories. The bias on the MB-CDI:WS toward words that begin with early developing phonemes is seen because these words are based on developmental data from children's typical early word productions and therefore reflect a natural artifact of the character of early vocabularies in toddlers. Another way to evaluate our data could be to create a proportion of words each toddler produces from each category out of the total possible words for the given category. This may control for the fact there are more early developing category words compared to middle and late developing.

We calculated a revised set of proportions, utilizing the total number of possible words in each category as the denominator, and conducted our analyses again. A similar pattern emerged where no significant differences were observed between the LTs and their language-matched counterparts (TDL group) on proportion of words produced in each consonant category. Differences emerged between the LTs and TDL groups compared to the TDA group (see Supplemental Material S3). We believe these patterns are consistent with our initial analysis and interpretation of the data and reinforce the overarching interpretation—that LTs use a lexical selection process similar to that of their language-matched peers.

Finally, there are additional limitations to using data from a preexisting repository. It is possible that some of our late-talking participants may have other conditions like autism spectrum disorder or global developmental delay. We also do not know the status of their receptive language abilities. Additionally, the majority of the participants were derived from households with high maternal education and thus it may be difficult to generalize our findings to the population as a whole. This fact is especially salient in light of the finding that even in our relatively highly educated sample, a difference in maternal education across the groups is associated with language delay. As we showed, the mothers in our LT group, even though the majority attended at least some college, were, on average, less highly educated than those from the two language-typical groups, suggesting that even this small difference may have some consequences for language development. Whether this finding reflects some hidden bias in the data, or a true association is another potential area for future research. Despite the limitations, this study leverages a large open-source database to extend our understanding of potential mechanisms that contribute to slow expressive language development.

Clinical Implications

Although intervention for late talkers generally focuses on increasing lexical diversity, it may be equally important to support the expansion of phonological repertoires within the context of early lexical intervention. Output interventions—such as back-and-forth babbling activities in which adults imitate children's preverbal babbling, then add changes on their turn to encourage variety in babbled phonemes (Goldstein & Schwade, 2008); drill play (Paul et al., 2018) in which the child is shown objects in a play context and is rewarded for producing a specific verbal response; or milieu teaching (Finestack & Fey, 2013) in which the adult provides models of verbal output and the environment is engineered to

"tempt" the child to reproduce the model—all have some evidence of efficacy in expanding both lexical and phonological repertoires. Other interventions for early language development focus on enriched input and implicit learning. These include indirect language stimulation (Fey, 1986) and, more recently, Vocabulary Acquisition and Usage for Late Talkers (Alt et al., 2014; Munro et al., 2021), which reports on its use with three toddlers that resulted in improvement both in expressive vocabulary and an increase in the toddlers' phonological inventories of both consonants and vowels. Thus, there is emerging evidence that both lexical and phonological development can be affected by early interventions. One implication of our findings may be that providing exposure, through intensified input and structured temptations to communicate, to more complex phonological structures in otherwise age-appropriate target words may be a fruitful strategy. Just as, in understanding the relations between language and cognition, researchers have invoked a "local homologies" model of mutually supportive relations between certain language behaviors and certain cognitive achievements (e.g., Thal & Bates, 1988), providing a carefully calibrated level of phonological complexity in input and targeted words may afford opportunities for phonological growth that can also support lexical development. Research is needed to explore this speculation, as well as the relative effects of various emerging interventions to provide guidance for clinicians working with this population.

Conclusions

This study finds that the phonological pattern of words added to the early lexicons of late talkers is generally similar to that of both language-matched and age-matched typical toddlers; that, the greatest proportion of words begin with early developing phonemes. This finding supports lexical selection as a mechanism, among others, that helps determine which words, of the many a child may understand, are produced first. Although marginal differences between our late-talking sample and younger language-matched toddlers were observed and merit further investigation; broadly, our findings support lexical selection as a bias observed in all of our toddler groups, both typical and language delayed. Moreover, the typical order of acquisition of consonant phonemes is seen to be reflected in the proportion of words beginning with consonants from each of the three broadly defined groups of early, middle-, and late-developing phonemes for both typical groups and the late talkers group. We interpret these findings to suggest that late talkers are following a delayed but otherwise typical path in the building of a lexicon based, in part, on a phonological foundation. We suggest that this finding provides some guidance to clinicians in developing programs for late talkers that aim to strengthen both phonological and lexical skills.

Data Availability Statement

The data used for analyses in this article are publicly available from the WordBank repository (https://wordbank.stanford.edu/data).

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