Title

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Word-Learning Biases Contribute Differently to Late-Talker and Typically Developing Vocabulary Trajectories

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Abstract

This study explores how the vocabulary growth trajectories of typically developing and late-talker children change in relation to their word learning biases. Forty late talkers and 44 typically developing toddlers visited the lab once a month for one year starting at about 18 months of age. Word-learning trajectories were tracked using a parent-reported vocabulary measure, and shape and material bias measures were collected using the novel noun generalization task each month. A two-level hierarchical linear model was utilized for the longitudinal analyses. Results indicate that, at the first visit, a stronger shape bias was significantly associated with a *larger* vocabulary in typically developing talkers. In late talkers, however, a stronger initial shape bias was associated with a *smaller* vocabulary. Over the course of the study, for every additional visit, stronger shape biases were associated with *larger* vocabularies in late talkers, but not in typically developing toddlers. Results for the material bias mirrored the shape bias results. These findings suggest different possible underlying mechanisms for the two groups of children, as well as avenues for the design of language interventions that might support young late talkers.

Keywords: vocabulary acquisition; word-learning bias; late talker; word learning

Vocabulary Acquisition

There is enormous variability in the vocabularies of young children just beginning to speak. By two years of age, an otherwise typically developing toddler may know as few as ten words or well over 300 (Fenson, 1993). These early differences in vocabulary size may lead to long term differences in learning and language skills (Rescorla, 2000). Understanding the mechanisms behind language development that give rise to these different trajectories is vital for informing further research and developing identification and interventions for those children who show delayed word learning.

As children learn words, they also learn important features of the objects represented by these words and how these features relate to word use in general. Children must learn the regularities in their world, such as all balls are round, and all toothpaste is, well, thick and pasty. Children's noun learning progresses from slow and laborious to fast and seemingly effortless. This may be due in part to understanding and taking advantage of the way languages organize categories in the world. For example, by their third year of life, children seem to know to generalize names for solid objects by shape, but names for nonsolid substances by material (Landau, Smith & Jones, 1988). These word learning biases are typically assessed using the novel noun generalization (NNG) task; the child is taught a novel name for a novel item and then asked which other items, matching the exemplar on one or more features, have the same name (Landau et al., 1988). These biases develop in tandem with vocabulary growth, such that when children accrue between 50 and 150 nouns, the tendency to attend to shape for solid objects emerges and becomes robust (Gershkoff-Stowe & Smith, 2004).

Late talkers are children who lag in their vocabulary size compared to their same-aged peers in the absence of any known developmental disorders. Although the label of "late talker" is not a clinical diagnosis in of itself, this group is often defined by being in the lower 25th percentile on productive vocabulary, which is typically measured by the MacArthur-Bates Communicative Inventory (CDI) (Fenson, 1993). However, different researchers use different cut-off points when classifying children as late talkers, ranging from the 10th to 30th percentile.

Evidence suggests that late talkers and typically developing children differ not only in their vocabulary size, but also in the way they learn new words. Thirty-month-old late talkers, when defined as falling at or below the 30th percentile on the CDI, show no or even opposite word learning biases compared to typically developing 30-month-olds do (Jones, 2003). Further, 30-month-old late talkers under the 10th percentile struggle learning new words through fast mapping (Weismer, Venker, Evans & Moyle, 2013). Even before they turn two, children in the top 25th percentile on productive vocabulary show different word learning biases than children in the bottom 25th percentile (Colunga & Sims, 2017). Specifically, these early talkers showed as strong a shape bias for solids as a material bias for nonsolids, whereas late talkers showed a robust shape bias for solids that might be overgeneralized to nonsolids. The fact that late talkers differ from typically developing children in their word-learning biases in the lab may mean that these children acquire language through different mechanisms.

The differences between late talkers and their typically developing peers have long-term impacts, with some late talkers showing persistent deficits in measures such as reading, writing, and oral language skills throughout elementary and middle school (Rescorla, 2000). Although many of the children labeled late talkers as toddlers do "catch up" to their typically-developing peers, there is a clear need to better understand how late-talker trajectories develop over time, as well as the factors that may influence this development (Heilmann, Weismer, Evans & Hollar, 2005). However, it is unknown exactly how word-learning biases relate to vocabulary growth throughout development, as previous work has investigated these relationships cross-sectionally. For example, the finding that 18-month-old late talkers have a shape bias (Colunga & Sims, 2017) but 30-month-old late talkers do not (Jones, 2003), could be a result of the different task demands of the different novel noun generalization tasks used with these different age groups, or it may suggest something interesting about the different developmental trajectories of children who catch up versus children who remain late talkers between 18 and 30 months of age.

To understand word learning in typically developing and late talkers, word learning biases and vocabulary size need to be examined longitudinally. For example, are late talkers who show stronger word learning biases at 18 months more likely to make greater gains over time? Is the positive relationship between word learning biases and vocabulary size in typically developing children suggested by cross-sectional work also present longitudinally? Further, is that relationship similar among late talkers? By investigating the relationship between vocabulary size as well as both the shape and material biases during the course of development, we can begin to understand the mechanisms that may give rise to the different developmental trajectories. The present study will investigate vocabulary growth trajectories of children over a 12-month period and their relations to word learning biases.

Current Study

The overarching goal of this project is to understand how the vocabulary growth trajectories of typically developing and late-talker children develop vis-à-vis their word learning biases. To accomplish this, we track both the vocabulary and the word learning biases of toddlers over a period in which rapid vocabulary growth is typically observed, 16 to 30 months of age, on a monthly basis for a year. Late talkers were oversampled to account for their expected increased variability. To the extent that there exists a feedback loop between word learning biases and words learned, we would expect a positive relationship between these two measures. This relationship might change throughout development, such that the shape bias for solids is stronger and more strongly related to vocabulary growth early on, and the material bias for non-solids shows a different pattern of development in relation to vocabulary size. Furthermore, if typically developing and late-talker children differ in their learning mechanisms, not just on their vocabulary size, these relationships between word learning biases and words known may differ between the two groups of children.

This study is the first attempt to track, longitudinally, the relationship between word learning biases and vocabulary size in late talkers and typically developing children. Though previous work has documented the relationship between the shape bias and vocabulary composition cross-sectionally (Perry & Kucker, 2019) and longitudinally (Gershkoff-Stowe & Smith, 2004) in typically developing children, and other work had looked at vocabulary growth longitudinally in late talkers (Heilmann et al., 2005) and at the relationship between shape bias and vocabulary cross-sectionally in late talkers (Jones, 2003), this is the first attempt to document the development of both the shape and material biases, longitudinally, in both late talkers and typically developing children.

Method

Participants

One hundred and twelve children were recruited for this study; children were 16-18 months of age at the first visit (M = 17.69, SD = 0.93). Twenty-eight children growing up in bilingual households were excluded for the present analyses, as previous research suggests early differences in the developmental trajectories of vocabulary growth of monolingual vs. bilingual children (e.g., Thordardottir, 2011). Toddlers visited the lab once a month for 12 consecutive months. Seventy-nine of the 84 children attended at least 10 of the expected 12 visits. Forty monolingual children scored below the 25^{th} percentile on the CDI at their first visit, and for the present analyses, these children will constitute the late talker group (CDI percentile M = 11.65, SD = 12.26). The typically developing group consisted of the remaining 44 children (CDI percentile M = 59.14, SD = 21.44). Participating children were screened for known sensory or cognitive developmental disabilities or disorders. Late talkers and their typically developing peers did not differ in their ages at visit 1 or on average throughout the study; $t(82) = 0.71$, $p = 0.48$, $t(82) = 0.73$, $p = 0.47$, respectively.

Materials

Children participated in the novel noun generalization task to assess both the shape and material biases at each visit. The stimuli consisted of a warm-up set made out of common objects, a novel solid test set, and a novel nonsolid test set. The warm-up set had an exemplar, a red plastic ball, two other balls (a tennis ball and a green and blue rubber ball), a plastic spoon, a toy carrot, and a toy cat.

Each solid set consisted of an exemplar and five novel choices; two that matched the exemplar in shape but differed in color and material, one that matched in color, one that matched in material, and another that matched in both color and material. The nonsolid set was analogous, consisting of an exemplar and five choices; two items matching the exemplar's material but differing in shape and color, a color match, a shape match, and a color and shape match.

There were three sets structured in the way described above. The three sets rotated through the study, visit 1 – set A, visit 2 – set B, visit 3 – set C, visit 4 – set A, such that each set was used every 3 months and a total of 4 times over the 12 visits that encompassed the study.

The Macarthur-Bates Communicative Development Inventory Words and Sentences (CDI) was completed by parents on each visit. The CDI consists of a 680-word checklist asking parents to indicate which words their child *says*. Although the CDI is a parent report measure it has been shown to be reliable and related to performance on child-based vocabulary measures (Fenson, 1993).

Procedure

Children visited the lab once a month for 12 months. At each visit parents filled out a CDI form measuring their child's productive vocabulary. Upon consent, children participated in one rotation of the NNG task measuring their shape bias for solid objects and their material bias for nonsolids. The procedure was modeled after Gershkoff-Stowe and Smith (2004). In the warm-up phase, the experimenter presented all six toys to the child and allowed him or her to look at them and handle and touch them for 30s before removing them outside of the child's reach. The child was then shown the exemplar ball and told, "look at this ball." Then, each child was asked to "get a ball" or get "another ball." If the child failed to retrieve a ball, the child was asked one more time, and finally was told "here's another ball," handed the ball, and was instructed to get it one more time. If the child got one of the nonball distracter items, he or she was told, "that's not a ball, that's a ____", then the distracter was replaced on the tray, and the child was asked again, "is there another ball?" The goal of the warm-up phase was to familiarize toddlers with the procedure and the idea that the display might have multiple things that were or were not in the category.

The procedure during the test phase with the solid and nonsolid novel sets was the same, except without feedback. Children were shown the exemplar and told, "look at this dax" and then asked to "get a dax" or "get another dax" for the solid set or "get more dax" or "get some dax" in the nonsolid set. Children were asked to get another (or more) until they indicated that there were no more, allowing children to accept or reject as few or as many items as they desired. The solid set was presented before the nonsolid set, and a five-minute break and change in testing rooms took place in between the two tests to minimize carry-over effects.

Bias scores were coded by noting the order in which children chose items as members of the queried category. The first choice got three points, second choice two points, and so on. For the solid set, the weighted scores for the items not matching in shape were subtracted from the weighted scores for the two shape-matching objects, yielding a score from -5 to 5. Similarly, the material bias score for the nonsolid set was calculated by subtracting the weighted scores for the two items matching the nonsolid exemplar in shape from the scores for the items matching the exemplar in material.

Data Analysis

We employed a two-level hierarchical linear model to investigate our longitudinal data. We are able to quantify longitudinal growth trends and explore the variation in these trends across individuals. The "level 1" analysis estimates parameters within child, which in turn become the dependent variable for the "level 2" analysis assessing between-child variables. Number of words known, taken from the CDI, was the main outcome of interest across the analyses. Level 1 consisted of each visit within child, whereas level 2 quantified individual characteristics across children (e.g. talker type). We first graphed the trajectories of all children in the study to help visualize the data (*Figure 1*). we elected to use a linear growth description. The graph also indicates great variability in both the initial and ending vocabulary sizes of the children, as well as their trajectories throughout the study. Because of this, we will investigate not only fixed effects but the variance of the modeled growth curves.

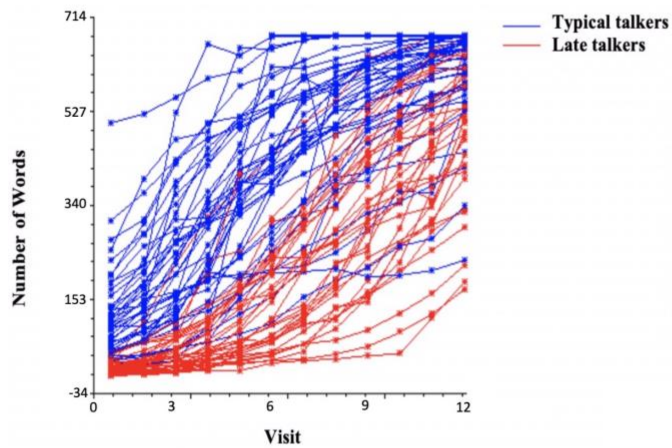

Figure 1: The raw data vocabulary trajectories for our full sample, color-coded by talker type. The x-axis is visit number, and the y-axis is the number of words the children produce from the CDI.

Model 1 Our first analysis seeks to describe the linear trajectories for all children in our sample, in order to establish a baseline for comparison. We centered Visit around visit one and allowed coefficients to vary at level 2. Figure 2 represents model 1 using the hierarchical linear modeling framework.

Level-1 Model: repeated observations of children

$$Vocab_{ti} = \pi_{0i} + \pi_{1i}(Visit_{ti}) + e_{ti}$$
$$where\ e_{ti} \sim iid,\ N(0,\ \sigma^2)$$

Level-2 Model: child characteristics

$$\pi_{0i} = \beta_{00} + r_{0i} \qquad r_{0i} \sim iid,\ N(0,\ \tau_{00})$$
$$\pi_{1i} = \beta_{10} + r_{1i} \qquad r_{1i} \sim iid,\ N(0,\ \tau_{11})$$

Figure 2: a representation of model 1 using the hierarchical linear modeling framework. This same structure will be used for analyses 2 and 3 as well, with added variables at level 1 and 2. For simplicity, we only present the general structure here.

Model 2 Our second analysis further investigates differences in growth trajectories between those children who were initially classified as late talkers (CDI < 25%) and those who were initially classified as typical talkers (CDI >25%). In our analysis, we examined the interaction between this talker type variable and both initial vocabulary size and linear growth. To do this, talker type status was placed at level 2 of the analysis as a between subjects variable, in order to predict the coefficients in our level 1 equation. Level 1 remained the same as in model 1. We centered our talker type variable to test the significance of both late and typical talker slopes separately.

Model 3a and b Our third analyses examine how the two word-learning biases of interest, shape and material, impact the number of words known by children both at visit one and over time. Here we investigate each bias separately. Further, we examine how these biases differentially impact the word learning trajectory for late talkers as compared to typical talkers. To do so, we add the bias score and the bias score by visit interaction to level 1 of our model. Level 2 remains similar to model 2, with talker type status predicting the intercept and visit coefficients. In addition, talker type is also placed in the level 2 equations for bias and the bias by visit interaction. Model 3a investigates the relationship between the shape bias for solid objects and vocabulary size at visit one and over the course of the study, whereas Model 3b does the same for the material bias toward nonsolid substances. A model including both shape and material bias, along with their interactions with each other and over visit, did not account for any more within-child variability in growth than models with either bias alone. Therefore, results will not be reported for such an analysis.

Results

Fixed affects for each model are presented in *Table 1* and variance components in *Table 2*.

Model 1

Results from model 1 indicate that, on average, children in our study had 63.27 words in their vocabularies at the first visit, or when 18 months old. For every month of the study, children, on average, accrued 47.05 new words, t(83)=28.51, p<.001. As expected, all children learned new vocabulary words as they aged. There was significant variability in both initial vocabulary size and visit slope; χ^2 (82, N=84) = 1554.80, p<.001, χ^2 (82, N=84) = 712.73, p<.001 respectively.

Model 2

Analysis 2 investigates differences in the word learning trajectories between late talkers and their typically developing peers (*Figure 3*). Typical talkers are predicted to have, significantly more words in their vocabularies at the first visit than late talkers; t(82)=8.99, p<.001. Both groups made significant vocabulary gains over time. Typical talkers were expected to add 48.19 words each visit, whereas late talkers were predicted to gain 45.53 words each month; t(82)=22.79, p<.001, t(82)=17.67, p<.001 respectively. In fact, vocabulary growth was not significantly different between the two talker types; t(82)=0.80, p=.427.

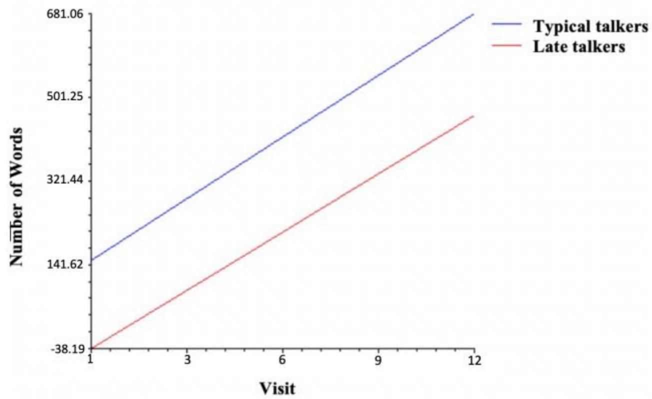

Figure 3: Predicted average vocabulary trajectory for typical and late talkers from model 2. Word-learning trajectories for both talker groups run parallel to each other

There is still significant variability in initial vocabulary size and linear growth; χ^2 (81, N=84) = 793.62, p<.001, χ^2 (81, N=84) = 710.86, p<.001 respectively. Knowing which talker type group a child belonged to did account for 51.85% of the variance between children's initial vocabulary sizes when compared to the first analysis. However, there was no appreciable difference in the variance of vocabulary growth from model 1 to model 2.

Model 3a – Shape Bias

Model 3a investigates how shape bias predicts both vocabulary size at visit one and over the course of the study (*Figure 4*). At the first visit, late talkers did not differ from their typically developing peers in shape bias scores; t(82)=1.61, p=.11. Controlling for shape bias score and its change over time, both late and typical talkers still, as in model 2, know significantly more words at each new visit. Typical talkers learn an average of 51.77 words a month and late talkers learn 41.84 words monthly on average; t(82)=21.18, p<.001, t(82)=16.75, p<.001. However, late talkers make significantly smaller gains in vocabulary size than their typical counterparts once shape bias and its changes over time were accounted for; t(82)=2.82, p<.01.

At the first visit, for every one-point increase in shape bias score, typical talkers were expected to know 6.05 more words, indicating that a stronger shape bias is significantly associated with a larger vocabulary in typically-learning talkers at the beginning of the study; t(82)=3.368, p<.001. In contrast, for every one-point increase in shape bias score, late talkers were predicted to initially know 7.44 fewer words -- for late talkers, a stronger initial shape bias was associated with a smaller vocabulary. This difference between shape bias and vocabulary size was significantly different for the two groups at their first visit; t(82)=6.069, p<.001.

For every additional visit, a one-point increase in shape bias score predicted a significant 1.39 word decrease in vocabulary size for typical talkers; t(82)=-4.885, p<.001. However, by the 10th visit, 43% of typical talkers already knew at least 90% of the words on the CDI, indicating possible ceiling effects in the typical talker group. Late talkers, on the other hand, showed a significantly more positive relationship between shape bias scores and vocabulary size over the 12-month study period; t(82)=7.216, p<.001. For each visit and one-point increase in shape bias score, late talkers were expected to know 1.61 more words; t(82)=5.31, p<.001.

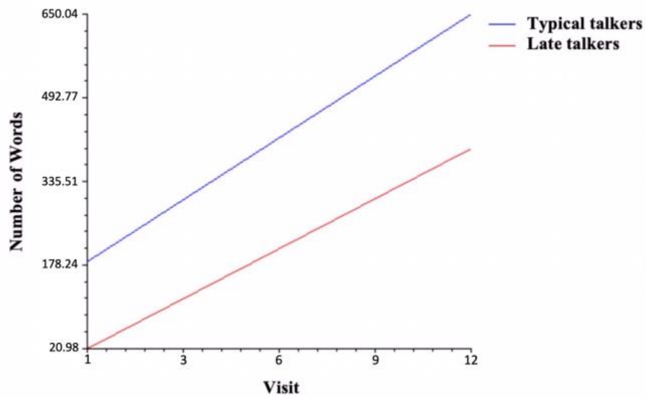

Figure 4: Predicted average vocabulary trajectory for typical and late talkers from model 3a. The words learning trajectories differ between late and typical talkers.

The inclusion of shape bias, its change over time, and how these variables differ between late and typical talkers in the model accounted for 8.7% of the within-child variability in vocabulary. However, there is significant variability in initial vocabulary size and growth; χ^2 (81, N=84) =455.60, p<.001, χ^2 (81, N=84)=475.46, p<.001 respectively.

Model 3b – Material Bias

Model 3b examines how the strength of a child's material bias predicts their vocabulary size at visit one and over the 12-month study period (*Figure 5*). At the first visit, late talkers did not differ from their typically developing peers in material bias scores; t(82)=1.02, p=.31. For a child with an average material bias strength at visit one and over time, both typical and late talkers are predicted to know significantly more words every month of the study, gaining 48.55 and 45.03 words, respectively; t(82)=23.07, p<.001, t(82)=17.50, p<.001. Further, these gains are not significantly different between the two groups; t(82)=1.06, p=0.291. This differs from when shape bias was controlled for, where late talkers did make significantly less gains in word knowledge than typical talkers.

At the first visit, for every one-point increase in material bias score, typical talkers are expected to know 4.32 more words, indicating a significant positive relationship between material bias and vocabulary size; t(82)=2.22, p<.05. The relationship between words known and material bias is significantly more negative for late talkers however; t(82)=3.54, p<.001. Late talkers are expected to know significantly less words (5.3) for every one-point increase in material bias; t(82)=-2.8, p<.01. This directly mirrors the results for shape bias.

The material bias by visit interaction also follows the same pattern as that for the shape bias. For every month aged, a one-point increase in material bias predicts a significant reduction in vocabulary size, by 0.95 words; t(82)=-3.06, p<.01. To note, this reduction in vocabulary size is not as large as the one for the shape bias, at a decrease of 1.39 words. Further, this relationship is significantly more positive for late talkers, as it was for the shape bias; t(82)=4.07, p<.001). For each month aged and a one-point increase in material bias score, late talkers are expected to know 0.92 more words; t(82)=2.72, p<.01. As the year goes by, a stronger material bias predicts more vocabulary gains for late talkers, but fewer gains for typical talkers.

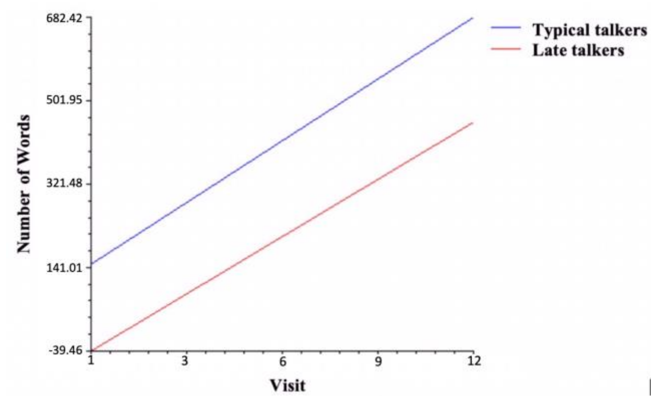

Figure 5: Predicted average vocabulary trajectory for typical and late talkers from model 2. The word-learning trajectories between late and typical talkers do not differ.

Including the material bias and its relationship with visit in the model accounts for about 5.9% of the variance at level one (as compared to 8.7% when shape bias was used). Variability in initial vocabulary size and linear growth are both significant χ^2 (81, N=84) =713.21, p<.001, χ^2 (81, N=84)=588.33, p<.001 respectively.

Table 1: Final estimation of fixed effects for the three analyses. Each intercept is the estimate for typical talkers. We indicate the coefficient for each variable followed by the significance (indicated *** p<.001, **p<.01, *p<.05). In parentheses are standard errors.

Fixed Effects	*Model 1*	*Model 2*	*Model 3a*	*Model 3b*
For Initial Vocabulary Size, π_{0i}				
Initial Vocabulary Size, β_{00}	63.27(14.6)***	150.93(18.5)***	132.24(18.3)***	148.26(18.2)***
Late talker, β_{01}		-189.11(19.6)***	-153.02(19.2)***	-187.70(19.6)***
For Visit slope, π_{1i}				
Visit slope, β_{10}	47.05(1.7)***	48.19(2.1)***	51.77(2.4)***	48.56(2.1)***
Late talker, β_{11}		-2.66(3.3)	-9.93(3.5)**	-3.53(3.3)
For Bias slope, π_{2i}				
Bias, β_{20}			6.05(1.8)***	4.32(2.0)*
Late talker, β_{21}			-13.49(2.2)***	-9.62(2.7)***
*For Visit*Bias slope, π_{3i}*				
*Visit*Bias, β_{30}*			-1.39(0.29)***	-0.95(0.31)**
Late talker, β_{31}			3.01(0.4)***	1.87(0.89***

Table 2: Final estimation of variance components for the three analyses. We indicate the variance component for each variable followed by the significance (indicated *** p<.001, **p<.01, *p<.05). In parentheses are standard deviations.

Variance Components	*Model 1*	*Model 2*	*Model 3a*	*Model 3b*
Initial Vocabulary Size, r_{0i}	17128(130.9)***	8246.53(90.8)***	7360.89(85.8)***	8139.87(90.2)***
Visit, r_{1i}	199.09(14.1)***	199.35(14.1)***	208.06(14.4)***	194.99(14.0)***
Bias, r_{2i}			14.24(3.8)	27.98(5.3)*
*Visit*Bias, r_{3i}*			0.63(0.8)*	0.79(0.9)*
Level-1, e_{ti}	3165.89(56.3)	3166.61(56.3)	2887.73(53.7)	2979.37(54.6)

Discussion

The work presented here looks at the differential contributions of word learning biases to the developmental trajectories of typically developing children and late talkers, and in doing so provides important novel insights. First, word learning biases may not be equally advantageous to all children. At the beginning of the study, typically developing talkers show the expected positive relationship between shape bias score and vocabulary size, suggesting that a shape bias facilitates word learning, in line with decades of work by Linda Smith and colleagues (e.g., Smith, 2000). However, the relationship between word learning biases and vocabulary size among late talkers presents a different pattern.

It is important to note that late talkers and their typically developing peers do not differ in their initial shape bias scores. Although this may seem to contradict Jones' (2003) finding that 30-month-old late talkers do not show a consistent shape bias, that is not the case. Rather, these results complement Jones' by documenting a different point in the developmental timeline; participants in our study were at least a year younger at the beginning of our study. In addition, we used an age-appropriate novel noun generalization task different from that in Jones (2003).

In contrast to the documented positive relationship between the shape bias and vocabulary size in typically developing children, among late talkers there is a negative relationship between the strength of their shape bias and their vocabulary size at the beginning of the study. This intriguing finding suggests our measure of the shape bias might not be distinguishing different underlying mechanisms that these two groups of children might be using. For example, it is possible, given the specific novel noun generalization task we used, that late talkers are exhibiting a generalized shape bias that is not linked to learning new words, but instead simply to attending to shape more generally. The fact that this same pattern of results held also for the material bias, however, suggests that this is not the case, and that at the very least they can shift their attention depending on the physical characteristics of the objects in front of them. Another possible reason our specific shape bias measure might not be detecting different underlying mechanisms is that we do not test retention. It is possible that in the short term, late and typical talkers generalize novel nouns in the same way (though there are documented differences in their fast mapping abilities; Weismer et al., 2013), but typically developing children have an easier time remembering the word-shape association over time, which would result in different rates of word learning in the real world.

Second, the relationship between word learning biases and vocabulary growth over time in the two groups of children might offer further clues. As the year goes by, we observe that among late talkers, increases in shape bias score is related to vocabulary gains. That is, the 18-month-olds who started as late talkers and grew up to have a robust shape bias by 30 months of age were likely not late talkers at all by that point. Here it is important to note that by the end of the study only seven out of the 39 children who started as late talkers, or about one in five, remained under the 25th percentile; about half of them were above the 50th percentile at the last visit. This could just be a function of the regular course of development, as it is well known that one of the difficulties of dealing with late talkers is that many of them will catch up without the help of any intervention as others will continue to struggle into their school years and beyond. In fact, Heilmann et al. (2005) suggest that the CDI can help identify children with low language skills up to the 11th percentile from children with normal language skills above the 49th percentile. Given that the majority of the late talkers in or sample (27/39) started the study under the 11th percentile mark, our rate of late talker recovery seems higher than expected. Is it possible that participating in this study helped late talkers acquire an effective shape bias? Whether that is the case or not, these findings suggest possible avenues for the design of language interventions that might support young late talkers.

On the other hand, for typically developing children, as the year goes by, increases in shape bias score are related to smaller vocabulary sizes. This unexpected finding is likely an artifact of typically developing children reaching ceiling performance in both the CDI and their word learning bias scores before the end of the study. Because the CDI is a finite set of about 700 words, the vocabulary curves of typical talkers artificially asymptote towards the end of the study, when in fact their vocabularies continue to grow as they acquire words beyond those listed in the CDI. One way to deal with this is to use open-ended diaries rather than vocabulary inventories to measure vocabulary. In addition, this would allow us to capture idiosyncratic differences in vocabulary composition in late talkers as well.

The present study, with the use of hierarchical analysis, sheds light on the differences in language acquisition between those who lag behind in vocabulary size, late talkers, and those that are developing typically. Although the present analyses are just a first step in understanding these trajectories, they suggest interesting targets for future work. With this knowledge, earlier identification of children at risk for delayed vocabulary acquisition, as well as the development of more targeted interventions for such children, might be possible.

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