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SHORT REPORT

When is a word in good company for learning?

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Abstract

Although identifying the referents of single words is often cited as a key challenge for getting word learning off the ground, it overlooks the fact that young learners consistently encounter words in the context of other words. How does this company help or hinder word learning? Prior investigations into early word learning from children's real-world language input have yielded conflicting results, with some influential findings suggesting an advantage for words that keep a diverse company of other words, and others suggesting the opposite. Here, we sought to triangulate the source of this conflict, comparing different measures of diversity and approaches to controlling for correlated effects of word frequency across multiple languages. The results were striking: while different diversity measures on their own yielded conflicting results, once nonlinear relationships with word frequency were controlled, we found convergent evidence that contextual consistency supports early word learning.

KEYWORDS
context diversity, language acquisition, lexical acquisition, word learning

Research Highlights

- The words children learn occur in a sea of other words. The company words keep ranges from highly variable to highly consistent and circumscribed.
- Prior findings conflict over whether variability versus consistency helps early word learning.
- Accounting for correlated effects of word frequency resolved the conflict across multiple languages.
- Results reveal convergent evidence that consistency helps early word learning.

1 | WHEN IS A WORD IN GOOD COMPANY FOR LEARNING?

Starting in infancy, children rapidly begin to amass vocabularies of hundreds of words. Occasionally, word learning might be assisted by clear-cut labeling events, such as "this is a dog," or "this is red." However, young learners far more often encounter words in a broader language context, such as a conversation or shared story book. Moreover, these contexts tend to vary from one instance of a word to the next. For example, from transcriptions of children's everyday language experiences, a sampling of the contexts containing "dog" includes, "I hope that cat doesn't chase my dog out of the house," "Should the dog be sleeping on that bed," and "Morgan, don't feed the dog" (MacWhinney, 2000). Importantly, this tendency is stronger for some words than others, with some words occurring in diverse, varied contexts, and others occurring in consistent, circumscribed contexts. How does the diversity of the company words keep shape a child's growing vocabulary?

This question of how diversity or variability (henceforth "diversity") shapes learning is fundamental in cognitive science, with plausible arguments for both a helping and a hindering role. For example, consider the challenge of learning to differentiate speech sounds in a native or second language. In principle, if the contexts in which a learner is exposed to different speech sounds also vary in other respects, such as the speaker, this may prove distracting and hinder learning. Alternatively, diversity in such noncentral characteristics may help the learner hone in on the key distinctions. Indeed, numerous findings attest that diversity in these characteristics actually aids speech sound learning (Rost & McMurray, 2009; Seidl et al., 2014), with similar evidence favoring diversity in other domains (e.g., Vukatana et al., 2015).

For the challenge of word learning in childhood, arguments have been put forth in favor of each competing possibility. One perspective posits that children learn words more readily in diverse, variable contexts containing many different words (Hills et al., 2010). The opposing perspective instead argues that children learn words more readily in consistent, low diversity contexts in which they are reliably accompanied by a circumscribed set of other words (Horst, 2013; Roy et al., 2015). As we review below, each perspective is backed up not only by logically compelling arguments about why diversity or consistency should support early word learning, but by evidence drawn from the real-world language contexts in which children encounter words day to day (Hills et al., 2010; Roy et al., 2015). The studies providing these opposing sources of evidence have been cited hundreds of times. These diametrically opposite findings leave the question of how the surrounding language context shapes early word learning with an unresolved conflict. This hinders not only our understanding of this question, but also attempts to build upon these prior findings. For example, these findings have motivated multiple ongoing efforts to design interventions that foster word learning (Frances et al., 2020; Joseph & Nation, 2018; Mak et al., 2021; Rosa et al., 2022, 2017). How can we resolve this conflict?

In what follows, we first review the rationale behind the competing perspectives, and the opposing evidence supporting each one. We then present a study in which we systematically triangulate the source of conflict and highlight a resolution.

1.1 | Contextual diversity versus consistency: Rationales and evidence

Multiple reasons have been proposed for why a diverse, variable company of other words might aid word learning. One argument is that diverse contexts help children disambiguate the meaning of a word from other candidates. This argument draws on the common observation that in any given use of a word, there is a potentially unlimited variety of referents that the word might map onto. In contrast, across situations, the true referent can be identified as the one that is consistently present along with the word while other candidates vary (Smith & Yu, 2008; Yu & Smith, 2007). From this basis, the argument for contextual diversity is that it is a proxy for the occurrence of a word across situations that help children zero-in on the true referent of a word because other candidates are highly variable (Hills, 2013; Hills et al., 2010).

Other arguments favoring contextual diversity take the perspective that knowledge about a word is not just a mapping to a referent, but its interconnections with other words. For example, knowledge of what "dog" means is not just its mapping to a particular group of animals, but comes from its interconnections with the words "pet," "cat," "friend," and so on. Thus, one argument that has built upon this perspective posits that diverse contexts build *richer* word knowledge (Bolger et al., 2008). A nonmutually exclusive argument is that human word knowledge is structured so that words that are likely to occur in any given situation are more accessible in memory. Thus, learners form more accessible representations of words that occur across a diverse variety of contexts (Adelman et al., 2006; Johns, 2021; Jones et al., 2012).

In contrast with arguments favoring contextual diversity, arguments that words are learned most readily in consistent contexts low in diversity focus on a central theme. Specifically, lower diversity is posited to simplify the challenge of word learning, allowing the child to gain a firm (though possibly narrow) sense of what a word means without the confusing, distracting complexity of occurrence with a diverse range of other words (Horst, 2013).

To arbitrate between the diversity and consistency positions, it is vital to examine how real-world word learning is shaped by *real-world language contexts*. Under real-world conditions, word learning comes from the gradual accumulation of exposure to words across noisy day-to-day contexts. Lab studies, while potentially illuminating, must vastly simplify these conditions. This presents a problem for contrasting diversity and consistency in the lab, especially given that the arguments in favor of consistency focus on how it may provide vital simplicity for a child facing the complex challenge of learning many words in noisy, real-world environments.

Given the importance of contrasting the effects of diversity versus consistency in real-world word learning and contexts, prior studies have sought to perform this contrast. Yet, far from resolving this question, prior studies have yielded conflicting evidence for both perspectives.

First, some studies have taken a large-scale approach. In this approach, diversity that is measured from everyday language contexts recorded across many children (Hills et al., 2010) has been used to predict when normative samples of young children learn words (Fenson et al., 2007; Frank et al., 2016). The results of these studies point to a supportive role for diversity, in which words that occur in diverse contexts tend to be learned earlier. Similar findings emerge from studies that have predicted normative age of acquisition (AoA) from proxies for diversity in everyday language, taken from the number of associations between a word and other words in adult free association norms (Fourtassi et al., 2020; Hills et al., 2009). In contrast, a pioneering study conducted by Roy et al. (2015) yielded the opposite pattern. This study collected a dense sample of the everyday language (as well as spatial and temporal) contexts experienced by one child from 9 to 24 months of age. From this dense dataset, the researchers found that earlier word learning—measured as the age at which the child first produced a word—was predicted by occurrence in consistent rather than diverse contexts. Together, these opposing findings pose a serious obstacle to understanding how word learning is shaped by the surrounding language context.

1.2 | Present study

The goal of the present study is to understand and resolve the conflict over whether diversity versus consistency in real-world language contexts supports early word learning. As noted above, this conflict exists within a larger ecosystem of questions surrounding diversity and consistency (Raviv et al., 2022). The focus of the present study is to tackle the opposing findings yielded by ostensibly similar prior studies of how everyday language contexts shape word learning in young children, using an approach that could prove useful in other domains where data on real-world input and learning are available (e.g., Sullivan et al., 2021).

To conduct this study, we considered potential sources of the conflict between prior studies. Perhaps the least interesting candidate is that the conflicting studies measured language contexts and word learning in different children. Ideally, any contribution of language context should generalize across children. Thus, the current study used normative measures of word learning and language contexts recorded from many children across multiple languages.

Of greater theoretical interest is that the conflicting studies have captured diversity in different ways. Some measures simply count the number of different words that a word occurs with (Hills, 2013; Hills et al., 2010). In contrast, others have sought to characterize contexts as more than just the words they contain. For example, different mealtimes may contain different words, while nonetheless being more similar to each other than a mealtime and a playtime. Thus, a word that occurs with "apple," "cracker," and "plate" might be thought of keeping less diverse company than one that occurs with "apple," "dog," and "airplane." Studies motivated by this consideration have used measures that incorporate the similarity between contexts (Roy et al., 2015). Therefore, we tested whether different measures might lead to different conclusions favoring diversity versus consistency.

The final source of conflict considered is how a word's contextual diversity is disentangled from its frequency. This is a key consideration because words that are more frequent are naturally likely to also occur with a wider diversity of other words. Moreover, higher word frequency is a predictor of earlier word learning above and beyond other important predictors such as word concreteness (Braginsky et al., 2019; Swingley & Humphrey, 2018) (for similar effects of frequency in word combinations and combinations of speech sounds, see Bannard & Matthews, 2008; Coady & Aslin, 2004; Edwards et al., 2004; Lavi-Rotbain & Arnon, 2022). The importance of this consideration is highlighted by a related line of research that has sought to illuminate the relationship between language contexts and ease of word processing in adults. Here, initial claims that diversity is a better predictor than frequency (Adelman et al., 2006) have recently been tempered by evidence that such claims were a spurious result of ineffectively controlling for the strong relationship between these factors (Hollis, 2020). Therefore, we tested whether disentangling diversity from frequency influences support for diversity versus consistency.

2 | METHODS

All measures, scripts for calculating measures, and scripts for conducting analyses are available on OSF https://osf.io/xuh3y/.

2.1 | Language contexts, vocabulary words, and word learning

All measures of contextual diversity were taken from the CHILDES corpus, a large set of transcribed recordings of everyday child language input. For a given language, the CHILDES corpus contains multiple datasets. Each dataset comes from a research project, and contains multiple transcripts. We followed the prior studies that have yielded conflicting findings by using English datasets, and also added Spanish, French, and German datasets to test whether patterns were consistent across multiple languages where large datasets are available. Prior to calculating diversity, we minimally preprocessed the corpora by (1) removing words with very low frequency overall (fewer than six instances) or that occurred in fewer than three datasets or transcripts (proportion of tokens removed: English = 0.86%, Spanish = 2.79%, French = 2.72%, German = 2.88%) and (2) lemmatizing morphological variants of words (e.g., singular and plural forms of nouns, tenses of verbs) to the same form, such as lemmatizing both "dogs" and "dog" as "dog"[1].

Following extensive precedent, we focused on vocabulary words assessed in the MacArthur-Bates Communicative Development Inventory (MB-CDI) (Fenson et al., 2007; Frank et al., 2016). The MB-CDI is a parent checklist of words and phrases common in early vocabularies (see General Discussion for richer vocabulary measures that may become available and provide further insight in future). We used MB-CDI data collected in the same languages as the corpora: English, Spanish, French and German. We focused on data from the Words and Sentences form of the checklist for 16–30 month-old children, in which

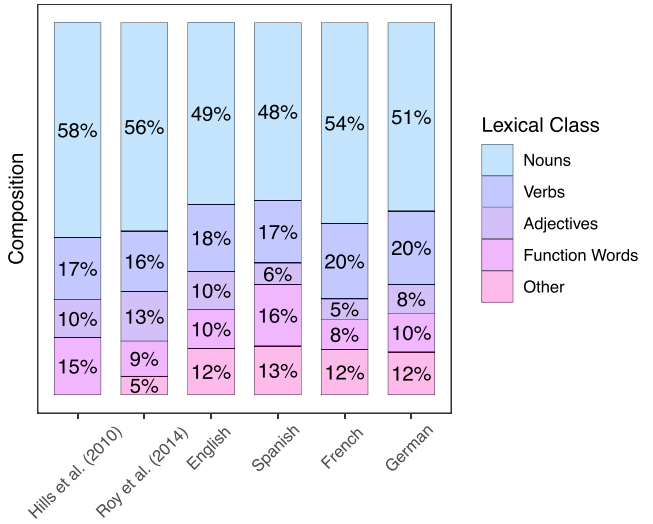

Figure 1 Proportion of words in each lexical class included in the MB-CDI used across languages in the present study, and in two studies that yielded opposing evidence for the role of contextual diversity: Hills et al. (2010) and Roy et al. (2015).

parents indicate whether their child produces each word. To estimate word learning, for each word in each language, we fit a logistic regression to estimate changes in the likelihood that children know the word with age. We then calculated the AoA as the age at which at 50% of children are likely to know a word. For each language, we only included words that also appeared in the corresponding CHILDES datasets (English = 584, Spanish = 431, French = 453, German = 467). As shown in Figure 1, the composition of words in lexical classes was similar across languages and two of the primary sources of conflicting evidence about the role of contextual diversity (Hills et al., 2010; Roy et al., 2015). For simplicity, analyses predicted AoA across all lexical classes (however, results were consistent when analyses were conducted separately within lexical classes; see Supplemental Materials).

2.2 | Diversity measures

We calculated two measures of diversity taken from prior research that has yielded conflicting findings: degree and divergence.

Degree. Degree is the simplest measure, taken from Hills et al. (2010). A word's degree is the number of unique words with which it co-occurs in a specified span or "window" of words. Degree can be calculated as the number of different words that occur only before, only after, or to either side of the target word within the window. Here, we focus on the total number of unique words that occurred before or after each of the target vocabulary words. However, equivalent findings transpired for the other approaches, which can be implemented using the code available on OSF. Following Hills et al., we log-transformed degree values. To test whether findings generalize across window sizes, we measured degree in windows of 5, 11, and 21 words (covering a range of windows tested in prior studies).

Divergence. Divergence is adapted from Roy et al. (2015). In contrast with degree, it is designed to quantify context as the overall conversation topic surrounding a word. For example, a low-diversity word might consistently occur with other words heard during mealtimes, though the specific words might vary from one mealtime to the next, whereas a high-diversity word might occur across a wide range of conversation topics. A full description of this measure can be found in the supplementary materials accompanying Roy et al., so we provide an overview here. The steps involved in calculating this measure can also be found in the analysis materials available on OSF. The motivating idea is that the combination of words present in any language "episode" (i.e., span of speech or text) emerges from a latent set of topics that each have an associated probability distribution of words. For example, children's everyday language experiences might cover "mealtime" topics that are associated with high probabilities of words for foods, "getting ready to go outside" topics associated with high probabilities of words for clothes, and so on. Roy et al. first used an unsupervised algorithm (latent Dirichlet allocation [LDA]), which jointly estimates both: (A) latent topics, which have probability distributions across words, and (B) a probability distribution across topics for each language episode. Next, Roy et al. computed each word's distribution of associations with different topics. Roy et al. then calculated an overall "background" distribution across topics, averaged across all language episodes. Finally, divergence of a word was calculated as the divergence between its distribution and the overall background distribution. Thus, words that diverged more from the background distribution were associated with a more consistent, idiosyncratic set of topic contexts.

Our adaptation of divergence was closely modeled on Roy et al., with the following exceptions. First, the unit of analysis for topic estimation in Roy et al. was 10-min spans of conversation. In contrast, the corpora used in the present study are divided into transcripts, which typically correspond to the speech recorded during a spontaneous family activity such as mealtime. Second, in the original implementation, higher divergence values corresponded to lower diversity. For simplicity and alignment with degree, we reversed the scale.

2.3 | Disentangling effects of frequency

The more frequent a word, the greater diversity of other words it will tend to occur with. We used two measures to disentangle frequency from diversity. First, we used the standard measure of word frequency, which is the log of each word's frequency in the corpus. The second measure was motivated by a recent study of frequency versus context diversity in adult lexical processing, which provides evidence that diversity measures may spuriously appear to account for variance above and beyond log frequency because they capture nonlinear effects of frequency that the log transformation does not account for (Hollis, 2020). Therefore, following Hollis (2020), we recalculated each diversity measure on shuffled versions of the language corpus that randomized the order of words. Shuffling eliminates any associations between words and their surrounding language contexts without affecting word frequency. Before shuffling, a word that occurred 500 times in similar contexts will have a lower contextual diversity value than a word that occurred 500 times in different contexts. After

TABLE 1 Illustration of the effect of shuffling on diversity measures.

Word	Freq	Degree	Shuffled degree
Kitty	3429	7.88	8.42
Our	3435	8.35	8.41

shuffling, the values for the word that originally occurred in similar contexts will increase to be similar to the word that originally occurred in different contexts, because both words will occur in the company of a random variety words. In this way, contextual diversity values calculated from shuffled corpora are a form of frequency measure. By the same token, controlling for values from shuffled corpora controls for the variance in contextual frequency that stems from word frequency (see Table 1 for an example).

There are two candidate approaches to disentangling each diversity measure from frequency: (1) test whether diversity predicts word learning after the variance in diversity that is accounted for by frequency has been removed by regressing it out, and (2) test whether diversity predicts word learning above and beyond frequency as a separate predictor. It is worth noting that one of the conflicting studies (Roy et al., 2015) used the first approach, whereas another (Hills et al., 2010) used the second. Here, we followed the first approach, because the second involves entering highly correlated variables as separate predictors, which can muddy the interpretation of results (Mansfield & Helms, 1982). Indeed, the second approach has yielded different findings in similar studies (Hills et al., 2010 versus Hills, 2013).

In our approach, we calculated the residuals of each measure left over after regressing out the effect of frequency, the measure calculated from the shuffled corpus, or both. This yielded: (A) original and (B) frequency-corrected versions of each diversity measure. Thus, we contrasted how each diversity measure predicted word learning both before and after controlling for frequency.

3 | RESULTS

To account for nonlinear relationships between diversity, frequency, and AoA, all regressions were conducted using Generalized Additive Models (GAMs). GAMs can capture nonlinear relationships between predictor and outcome variables using smoothing functions applied to ranges within the predictor variable(s). All GAMs were constrained to be monotonic so that the relationship between predictor and outcome variables could only be either positive or negative. GAMs were fit using the scam package (Pya, 2023) in the R environment. We found similar results when GAMs were replaced with linear regression (see Supplemental Materials).

3.1 | Diversity and frequency

We first evaluated the degree to which variance in each diversity measure was explained by the two frequency control variables: log frequency, and the diversity measure calculated from shuffled corpora. Figure 2 illustrates the relationship between diversity and frequency in English. This relationship was consistent across all four languages (Table 2). These strong relationships underscore the importance of controlling for frequency.

TABLE 2 Variance in diversity explained by frequency control measures (Log Freq and Shuffled).

Language	Degree		Divergence	
	Log Freq	Shuffled	Log Freq	Shuffled
English	0.99	0.98	0.43	0.42
Spanish	0.99	0.99	0.35	0.33
French	0.99	0.99	0.61	0.60
German	0.99	0.99	0.33	0.32

3.2 | Diversity and word learning

To examine the relationships between diversity and word learning, we contrasted the original and frequency-corrected variants of each diversity measure as predictors of AoA. As described above, frequency-corrected variants consisted of the residuals left over after regressing the effect of frequency. In total, there were four variants of each diversity measure: the original raw measure, and variants corrected for log frequency, diversity calculated from the shuffled corpus, or both.

We fit a series of GAMs with AoA as the outcome variable, and the four variants of each diversity measure as the predictor variable. To estimate whether greater diversity was associated with earlier or later AoA, for each diversity measure variant, we contrasted two GAMs: one in which the relationship was constrained to be negative (greater diversity predicts earlier AoA), and one in which the relationship was constrained to be positive (greater diversity predicts later AoA). From this contrast, we selected the winning GAM as the one that accounted for the most variance in AoA. From each winning GAM, we took the amount of variance explained by diversity.

The results of these analyses across languages are shown in Figure 3. Because results were consistent across window sizes, for simplicity, the results for Degree in Figure 3 depict only the measure from the window size of 5 (see Supplemental Materials for all window sizes, as well as a replication of results within word classes). This figure illustrates that when the diversity measures are not corrected for frequency, results differ between the two measures and across languages. However, all frequency-corrected variants yielded the same result: lower diversity predicts earlier AoA. As shown in Figure 3, this convergence occurs because frequency-correction changes the direction of the relationship between AoA and Degree, so that like Divergence, lower diversity words tend to be learned earlier (see Hills, 2013, for similar)[2]. Moreover, frequency-correction strengthens this relationship for Divergence across languages. These results provide convergent evidence that lower diversity fosters earlier word learning.

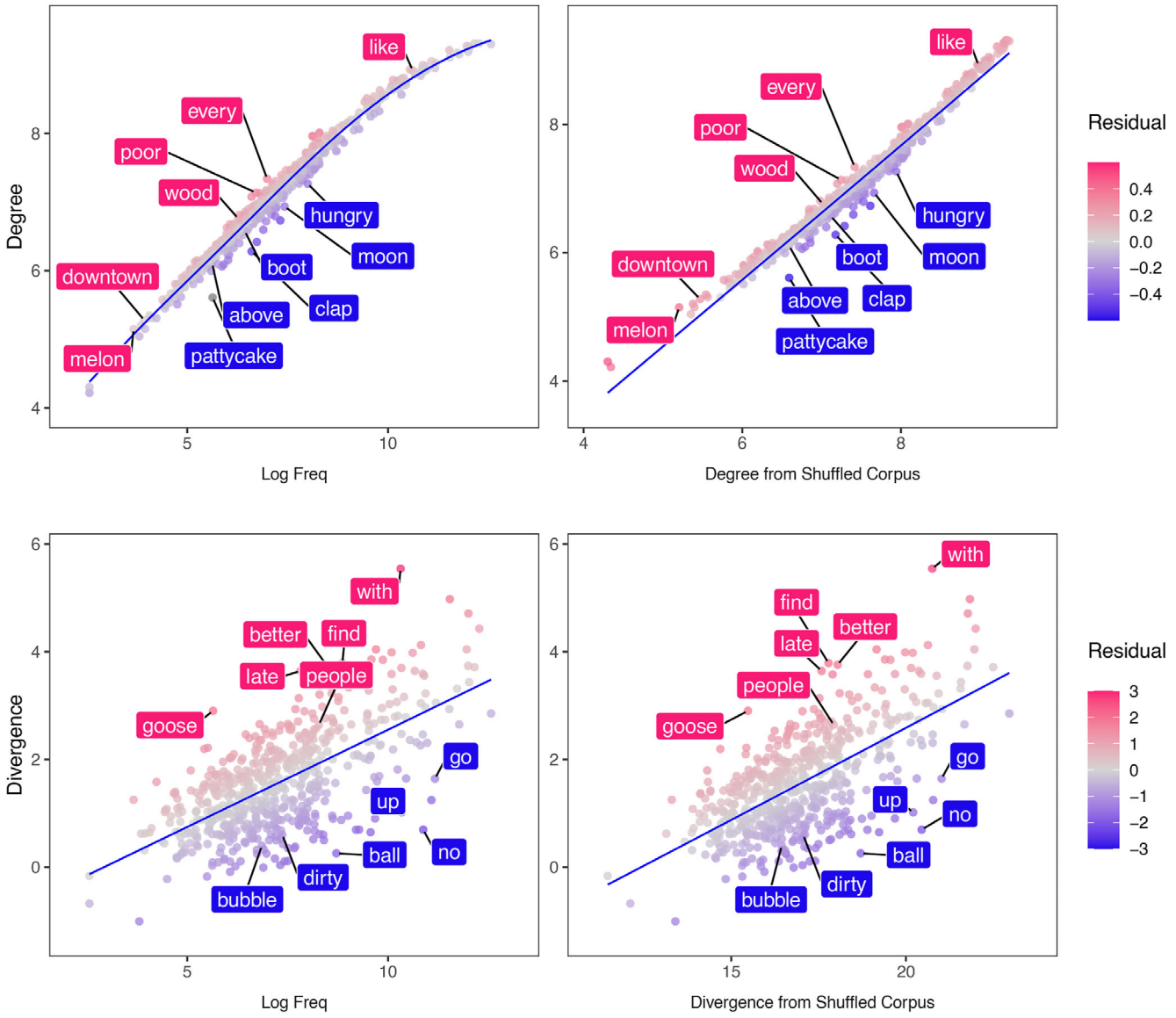

Figure 2 Relationship between each diversity measure (rows) and frequency control measure (columns) in English. For each diversity and frequency control measure, the line depicts the relationship estimated using a Generalized Additive Model (GAM). Points depict individual words, colored according to their residuals after controlling for frequency. Words in text boxes show illustrative examples of words with positive and negative residuals.

4 | DISCUSSION

Do young children learn words more readily when they are accompanied by a diverse range of other words, or a consistent, circumscribed set of other words? Any attempt to seek the answer to this question in prior studies would yield conflicting evidence for both possibilities (Hills, 2013; Hills et al., 2010, 2009; Roy et al., 2015), even from ostensibly similar studies that tested whether similar measures of word learning are predicted by diversity or consistency in real-world language contexts.

The results of the present study resolve this conflict. First, measures of diversity used in different studies were strongly correlated with word frequency, as frequent words naturally occur with a wider range of other words. Without disentangling diversity from frequency, the relationship with word learning was mixed across diversity measures and languages. In contrast, when frequency was controlled, the results were striking: all measures convergently suggest that words are learned earlier in consistent contexts low in diversity.

4.1 | Changes with development and word knowledge depth

The focus of the present study was on resolving a conflict surrounding the role of contextual diversity in early word learning. The support for contextual consistency converges with evidence from empirical studies of early word learning, much of which comes from studies of young children learning new words from storybooks. Findings from these studies

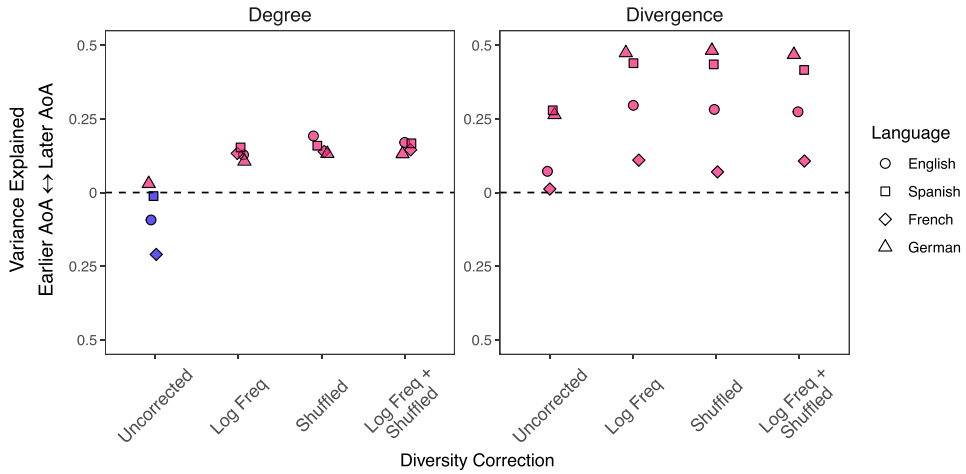

Figure 3 Predicting age of acquisition (AoA) from the four variants of each diversity measure. The variants of each measure are shown on the *x*-axis: the original raw measure, and the measure corrected for each or both of the frequency control measures. The *y*-axis represents the proportion of variance in AoA explained by a diversity measure. Different points correspond to different languages. Points shown in pink above the dashed line indicate that larger values of the diversity measure predicted later AoA, and points shown in blue below the dashed line indicate that larger values of the diversity measure predicted earlier AoA.

reveal better word learning when new words are repeatedly encountered in the context of the same storybook, versus different storybooks (Horst et al., 2011; McLeod & McDade, 2011; Williams & Horst, 2014) (for similar findings for other types of context, see Axelsson & Horst, 2014; Horvath & Arunachalam, 2021; Maguire et al., 2008).

At the same time, it is important to note that the support for contextual consistency differs from conclusions drawn from prior analysis approaches that have instead supported a positive role for contextual diversity in early development, including evidence for greater contextual diversity in the language input to typical versus late talkers (Jiménez & Hills, 2023) and some analyses of multiple predictors of early word learning (Stella et al., 2017) (see also evidence favoring a role of diversity in word segmentation, e.g., Saffran et al., 1996). Therefore, it will be valuable to investigate whether the present approach resolves these apparent conflicts as well, or whether further sources of discrepant findings need to be explored. Moreover, although the present approach of disentangling contextual diversity from frequency is grounded in evidence that frequency is an important predictor of the ease with which young children learn words (Braginsky et al., 2019; Swingley & Humphrey, 2018) (as well as other language units, e.g., Coady & Aslin, 2004; Edwards et al., 2004; Lavi-Rotbain & Arnon, 2022), concerns have been raised about whether and how frequency directly contributes to word knowledge in adults (Baayen, 2010). Therefore, further consideration is merited about the mechanistic contributions of frequency and contextual diversity to word learning.

In addition, both new and familiar words are encountered in the company of other words throughout childhood and into adulthood. It is, thus, important to consider how the role of diversity may change as learners develop and gain increasingly rich word knowledge.

Several studies have explored whether empirically manipulated contextual diversity contributes to word learning in older children and adults. Evidence from these studies is mixed, with some studies finding a supportive role for low contextual diversity in the early stages of learning that is aligned with the present findings (Hulme et al., 2023; Mak et al., 2021, Experiment 1), and other studies instead finding a supportive role for *high* contextual diversity (Frances et al., 2020; Johns et al., 2016; Joseph & Nation, 2018; Rosa et al., 2022, 2017) (see also Adelman et al., 2006; Hollis, 2020; Johns, 2022; Johns & Jones, 2022, for conflicting evidence regarding the ease of processing familiar words in adults).

These mixed findings point to the intriguing possibility that the contribution of contextual diversity changes with improvements in word knowledge and development. Early on, word learning is likely a relatively shallow matter of learning to articulate the speech sounds of a word, perhaps in a roughly appropriate situation (e.g., saying "dog" in the presence of any furry animal, or just the family's dog). With experience, word knowledge becomes increasingly refined and enriched (Gershkoff-Stowe, 2001; Rigler et al., 2015). Diversity may be increasingly useful for further learning after the child has gained an initial grasp of a word. This possibility is consistent with evidence from multiple domains that lower diversity is beneficial when learning is first getting off the ground, whereas higher diversity is beneficial after some learning has already taken place (Mak et al., 2021; Raviv et al., 2022). A similar dynamic might characterize the contribution of contextual diversity with development. Early in development, when children must learn new words along with many other things from scratch, contextual consistency may help simplify the learning challenge. With age comes improvements in prior knowledge, as well as maturational changes that may support learning, such as increases in working memory capacity and attention (Fry & Hale, 2000). As these developmental changes unfold, children may be able to reap the posited benefits of contextual diversity described above, including disambiguation from other words, richer representations of word knowledge, and improved ease of access in memory.

Within word learning, changing contributions of diversity with maturation could be explored using the approach from the present study

given normative word learning (Brysbaert & Biemiller, 2017) and emerging corpora of language input to older children (Korochkina et al., 2023). Similarly, changing contributions of diversity with increasing word knowledge depth could be explored with ongoing improvements in measures of early word knowledge (Zettersten et al., 2022).

4.2 | What form of contextual diversity matters?

We evaluated two previously developed measures of contextual diversity: Degree, which captures the number of different words accompanying a word, and Divergence, which captures the variety of conversational topics in which a word occurs. Despite the conceptual distinction between these measures, they produced equivalent results after correcting for frequency, in which lower contextual diversity predicts earlier ages of acquisition. While resolving conflicts between these measures in prior research (Hills et al., 2010; Roy et al., 2015), this outcome leaves open the question of which form of contextual diversity matters for word learning. Future work could attempt to tease apart these predictors via corpus analyses as in the present research, or by empirically manipulating word learning contexts for children.

4.3 | Conclusion

The real-world environment for word learning is a noisy place, in which words are encountered not only in the presence of a variety of potential referents, but also in the company of other words. Here, we sought to resolve a conflict in the literature regarding how the company of other words helps or hinders word learning. We found that although different measures of the diversity versus consistency of this company yield conflicting results on their own, convergent support for consistency emerged upon controlling for confounds with word frequency. The resolution of this conflict provides a stable ground for pursuing further insight into how word learning is shaped by everyday, real-world experience.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest with respect to their authorship or the publication of this article.

DATA AVAILABILITY STATEMENT

Data and scripts have been made available via the Open Science Framework at https://osf.io/xuh3y/.

ETHICS APPROVAL

All activities involved in this research were approved by the Institutional Review Board at The Ohio State University.

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ENDNOTES

[1] The inclusion of additional languages with available CHILDES corpora would be desirable but was precluded due to inability to verify the accuracy of currently available lemmatization tools.

[2] We speculate that controlling for frequency changes the apparent direction of the relationship between Degree and AoA because Degree is particularly strongly correlated with frequency, which predicts earlier word learning (Braginsky et al., 2019; Swingley & Humphrey, 2018). Thus, like frequency, higher uncorrected Degree predicts earlier word learning. This relationship disappears once the variance due to frequency is regressed out. In contrast, higher frequency predicts earlier word learning both before and after partialling-out variance due to contextual diversity (script available on OSF).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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