Cognitive Development 78 (2026) 101676



Contents lists available at ScienceDirect

Cognitive Development

journal homepage: www.elsevier.com/locate/cogdev



Seeing the big picture: How early-learned nouns and their referents co-occur in children's picture books

Amanda Mankovich [a,b], Sumarga H. Suanda [a,b,*]

[a] Department of Psychological Sciences, University of Connecticut, Storrs, CT, USA
[b] Institute for Brain and Cognitive Sciences, University of Connecticut, Storrs, CT, USA

ARTICLE INFO

Keywords:
Picture books
Word learning
Visual statistics
Language development

ABSTRACT

Shared picture book reading is well established as an activity with potential to boost vocabulary acquisition. One way that cognitive and developmental scientists have sought to better understand the potential mechanisms by which reading picture books supports acquisition is through detailed examinations of the content of these books. Such analyses have revealed different ways in which the linguistic elements of children's picture books are both rich and distinct from those observed in child-directed speech, raising the possibility that the linguistic environment promoted by shared book reading may be key to its power. The current study provides data to suggest that the *visual* elements of children's picture books may also deserve some consideration. In an analysis of 128 picture books commonly read to children in North America, we found that the visual depictions of early-learned nouns are in line with research on what facilitates early word learning in three specific ways: (1) nouns and their referents co-occur at high rates, (2) noun-referent co-occurrence patterns are tightly aligned temporally, and (3) the referents of early-learned nouns were visually frequent. Further analyses reveal how some of these properties were more prominent for the earliest learned nouns and in books targeting the youngest of audiences. The implications of these findings for how children learn from picture books and for the learning environment that is cultivated by reading them are discussed.

1. Introduction

Picture books convey stories through a thoughtful combination of text and illustrations. As scholars of this literary form have long noted, there is a multitude of ways in which this combination plays out (for a review, see Sipe, 2012). In some cases, a picture book's text and illustration communicate information in a way that is largely redundant to, or congruent with, one another (Schwarcz, 1982). In other cases, the text and illustration play a more complementary role where the words constrain the region of focus in its corresponding illustration, and the illustration limits the possible interpretations of its corresponding text (Nodelman, 1988). Yet in other cases, the relationship is one of counterpoint, where text and illustration convey separate emphases to communicate different perspectives of the same events, to convey different plots within a story, or to express different messages to the child listener and adult reader (see Nikolajeva & Scott, 2001). Scholars in the developmental and learning sciences have explored the implications of the ways in which picture books' text and illustrations relate on a number of topics, including how they support story comprehension (e.g.,

* Correspondence to: Department of Psychological Sciences, University of Connecticut, 406 Babbidge Road, Unit 1020, Storrs, CT 06269-1020, USA
E-mail address: s.suanda@uconn.edu (S.H. Suanda).

https://doi.org/10.1016/j.cogdev.2026.101676
Received 23 August 2024; Received in revised form 29 January 2026; Accepted 30 January 2026
Available online 9 February 2026
0885-2014/© 2026 Elsevier Inc. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

Martinez & Harmon, 2012; Wagner, 2013), how they cultivate social emotional learning (e.g., Dyer et al., 2000; Garner & Parker, 2018), and how they develop mathematical and scientific thinking (e.g., Elia et al., 2010; Marriott, 2002; Ward et al., 2017). In the current study, we seek to understand how the synergy between a picture book's text and its illustrations supports a different facet of cognitive and linguistic development, the process of linking words to their meanings.

This interest in the implications of the structure of children's picture books for word learning stems in large part from the fact that besides being forms of art, picture books may play an important role in promoting children's early language and literacy development (Dickinson et al., 2012; Flack & Field, & Horst, 2018; Noble et al., 2019). Thus, understanding with greater precision the candidate pathways by which picture books shape learning is of great interest in the cognitive, developmental, and learning sciences (see Horst & Houston-Price, 2015; Kümmerling-Meibauer & Meibauer, 2015; Nation et al., 2022). The current study seeks to contribute to this understanding by examining how words and their referents co-occur in commonly read children's picture books. Of special interest is whether their co-occurrence patterns embody patterns recently identified to boost word learning in studies of child-directed speech (Bergelson & Aslin, 2017; Bergelson & Swingley, 2013; Casey et al., 2023; Clerkin & Smith, 2022; Yu & Smith, 2012; West et al., 2022). If they do, then the relation between a picture book's illustration and its text may be an important, and arguably under-explored, pathway by which picture book reading supports early language development.

1.1. *How word-referent relations support word learning: Co-occurrence rates, temporal alignment, and referent visual frequency*

The broad notion that the relationship between a word and its extralinguistic context is important for word learning dates back at least to the accounts of language development expressed by Saint Augustine of Hippo in 401 AD (Pusey,1907). Exactly what it is, however, about the link between a word and its extralinguistic contexts that is key for learning, and thus for what one might look for when examining children's picture books, is still unsettled science all these years later. Some research suggests that the co-occurrence patterns themselves may be important for learning (Bergelson & Aslin, 2017; Bergelson & Swingley, 2013). For example, Bergelson and Aslin found that the extent to which a word's referent was present in a child's surroundings as their caregiver uttered that word predicted the extent to which that child exhibited understanding of that word in a laboratory-based comprehension assessment. Although of course this work is correlational in nature, it is suggestive of the importance of word-referent co-occurrence for learning (see also Casey et al., 2023; Clerkin & Smith, 2022; Perry et al., 2022; Suanda et al., 2019; West et al., 2022) and is consistent with experimental data on young children's ability to learn words via tracking word-referent co-occurrence patterns (e.g., Smith & Yu, 2008; Suanda et al., 2014; Vlach & Johnson, 2013; Vouloumanos & Werker, 2009). Thus, in a consideration of the learning potential of picture book features, one relevant variable to examine is the co-occurrence rates of words and their referents.

Other research has examined how the nature of word-referent co-occurrences, and not just the co-occurrence rates themselves, is

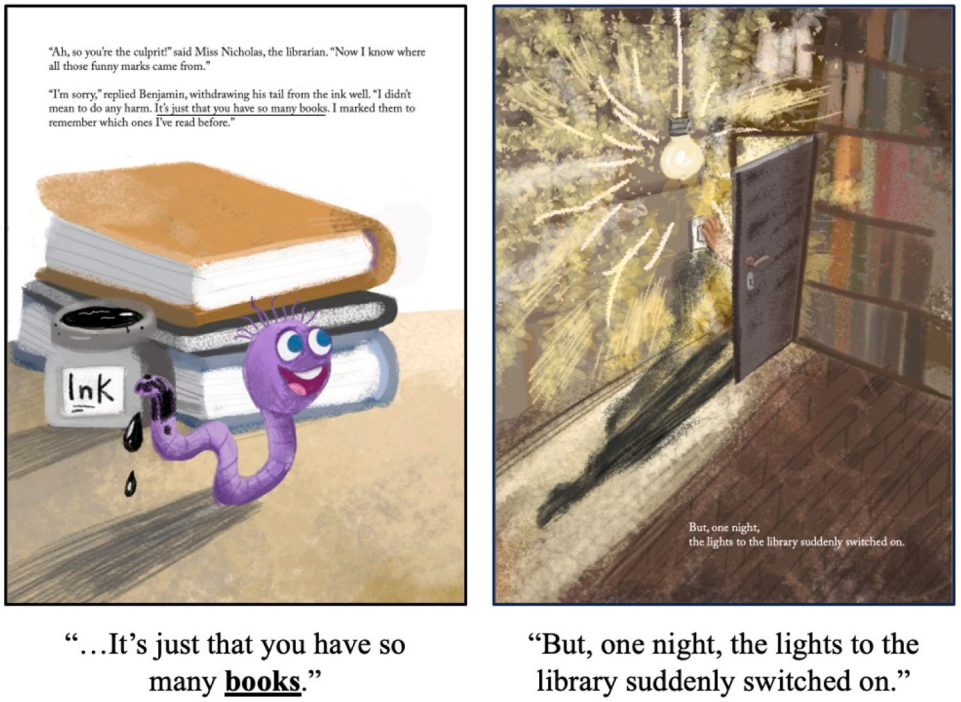


Fig. 1. *Example of the Visual Occurrence of a Word's ("Book") Referent Note.* This figure is an illustrative example of how a word ("book") and its referent occur on two pages in a children's picture book. Although the word only occurred on the left page, the referent of the word is visible on both pages. These pages come from "Books for Benjamin" (de Rouen, 2022), which is released under CC BY 4.0 license.

vital for learning (see Golinkoff et al., 2015; Rowe & Snow, 2020; Tamis-LeMonda et al., 2014). Although there are many aspects of these co-occurrences that have been found to be relevant for learning in studies of dyadic interactions, one that is applicable to studying the properties of children's picture books is the timing of the word-referent co-occurrence. In one early word learning experiment, Whitehurst and colleagues (1982) presented two-year-old children with an English word unfamiliar to the children (e.g., "map", "wick") in the context of its referent. Across different conditions, the researchers varied the presentation timing of the referent such that words and their referents were either presented simultaneously or separately with varying time lags. What Whitehurst and colleagues observed is that children learned the word-referent mappings best when words and their referents were presented simultaneously and that children's learning was disrupted when there was a lag in presentation (Whitehurst et al., 1982; see also Masur, 1982; Roth, 1987). Although the extent to which precise alignment is *necessary* for learning has since been questioned (Baldwin, 1993; Tomasello & Barton, 1994), a number of recent studies with different designs have supported the notion that precise alignment does add value, especially for young word learners (see de Villiers Rader & Zukow-Goldring, 2010; Lany et al., 2022; Gogate & Bahrick, 1998; Nomikou et al., 2017; Pereira et al., 2014; Trueswell et al., 2016; Yu & Smith, 2012). The lesson for the current study then is that examining the temporal dynamics of word-referent co-occurrences would speak to the quality of the learning environment picture books offer.

One final set of studies that motivated the current work is recent research suggesting that a child's visual experiences leave their fingerprints on word learning in more ways than just through how they co-occur with language. Specifically, in a series of studies that used infant-worn head-mounted cameras to capture infants' early visual environments, Clerkin, Smith, and colleagues, observed correlations between the frequency with which an object (e.g., a spoon) was in view and the extent to which that object's name is known to young word learners. That is, objects whose names are normatively acquired by 16 months were more likely to be observed in the infants' visual environments than objects whose names are normatively acquired later in development (Clerkin et al., 2017; Clerkin & Smith, 2022). What this research suggests is that the relevance of the visual world for word learning may not be limited to the moment the word is encountered (i.e., the moment of word-object co-occurrence). Instead, the visual world's role may be in building up the visual representations that allow for seamless learning when the word does occur (see also Kucker & Samuelson, 2012; Slone et al., 2019; Vong et al., 2024). The implication of this finding for the current investigation is that it may be relevant to consider not only the visual presence of a word's referent at the exact moment the word is presented, but also the frequency of that referent throughout the book, including the pages where the word was not present (see Fig. 1).

1.2. *Word-referent relations in picture books as an input source for word learning*

The current study examines whether the above word-referent properties revealed to be supportive of early learning – high co-occurrence rates, tight word-referent alignment, and high referent visual frequency – are properties that characterize how words and their referents are presented in commonly-read picture books in North America. Although a growing number of picture book corpus analyses have highlighted picture books' unique and valuable textual properties (for review, see Nation et al., 2022), few of these analyses have considered the potential contributions of picture book illustrations to learning. Given the centrality of illustrations to the picture book genre (Nikolajeva & Scott, 2001; Nodelman, 1988), the evidence that children are drawn to the illustrations during picture book reading (Evans & Saint-Aubin, 2005; Justice et al., 2005; Yaden et al., 1989), and the research described above highlighting the role that the visual properties of a word's referent plays in word learning, a more complete understanding of how the features of picture books support language development calls for a consideration of its illustrations along with its text.

It is important to clarify and stress that the current study is not the first to examine how picture book illustrations affect word learning (for discussion, see Kümmerling-Meibauer & Meibauer, 2013; Strouse et al., 2018). For example, a number of studies have explored how certain illustration properties, including their format (e.g., photographs vs. line drawings; see Ganea et al., 2008; Weber & Colunga, 2022), their theme (e.g., fantastical vs. realistic; see Weisberg et al., 2015), how they are laid out within a book (Flack & Horst, 2018), and whether they are accompanied with manipulative features (e.g., pop-ups; see Chiong & DeLoache, 2013; Tare et al., 2010), can all influence word learning. Separately, it is also worth noting that research in a variety of educational contexts, from science and technical education (Carney & Levin, 2002) to second-language learning (Dziemianko, 2022), has shown that pairing relevant visuals with text facilitates learning outcomes. None of these studies, however, have looked at the three specific variables discussed above. Perhaps more importantly, much of this existing research is experimental in nature and thus does not speak to the current study's goal of documenting the extent to which commonly read picture books possess the visual properties known to be supportive of word learning. A small number of studies have explored this question and thus had goals that overlap more closely with those of the current study (Dyer et al., 2000; Ward et al., 2017). Most notably, as part of an investigation into children's picture books as a source for learning about mental state terms, Dyer and colleagues (2000) investigated the extent to which mental state terms in picture book text (e.g., "feel", "think") co-occurred with pictures that were illustrative of the text. Interestingly, Dyer and colleagues found that these co-occurrence rates were rather low (see also Wellman et al., 1996), raising the possibility that extensive word-referent co-occurrence may not be a prominent feature of children's picture books. Alternatively, the trends Dyer and colleagues found may be specific to mental state terms and not representative of other word categories. After all, the extralinguistic contexts in which mental state terms occur in child-directed speech have also been found to be under-informative for learning their meanings (see Bergelson & Swingley, 2013; Gleitman et al., 2005; Snedeker & Gleitman, 2004). Either way, given that the current study will focus on the visual correlates of a different category of words (i.e., early-learned nouns), as well as a number of variables beyond co-occurrence, the current study will expand upon our current understanding of word-referent relations in children's picture books.

1.3. Current study overview

The current study examines the visual properties of the referents of early-learned nouns in 128 picture books commonly read to children in North America (Hudson Kam & Matthewson, 2017; Montag et al., 2015). More specifically, this study focuses on the three visual properties reviewed above: word-referent co-occurrence (i.e., the extent to which the referent of a noun is present in the illustration on the page in which the noun occurred), word-referent temporal alignment (i.e., the degree to which the referent of a noun is present in the illustrations on the pages before and after the noun occurred), and referent visual frequency (i.e., the degree to which the referent of a noun is present even in illustrations where the noun had not occurred). This study also investigates two additional research questions. First, we asked whether these visual properties would characterize some nouns over others. More specifically, following the work linking the visual correlates of child-directed speech to children's word learning (see Bergelson & Aslin, 2017; Clerkin et al., 2017; Clerkin & Smith, 2022), the current study asks whether nouns that are normatively acquired earliest in development would be more likely to possess the above visual properties in children's picture books. Although such a trend would merely be correlational and be open to several interpretations, it would represent one step towards characterizing the nature of the input in children's picture books and point to candidate future directions in further exploring that input. Second, because the focus of the current study was on whether picture books possess visual properties that might support early word learning, we asked whether these properties differed across books that targeted younger (0- to 3-year-olds) and older (4- to 8-year-olds) audiences. Our hypothesis, motivated by previous studies documenting differences in the illustrations of picture books targeting children of different ages (see Kümmerling-Meibauer & Meibauer, 2015; Kuwabara et al., 2020), is that picture books targeting the youngest of learners would be more likely to possess the visual properties that support early word learning.

2. Methods

2.1. Picture book corpus

The 128 picture books studied here were selected largely due to their use in previous research (Cameron-Faulkner & Noble, 2013; Hudson Kam & Matthewson, 2017; Montag et al., 2015; Wagner, 2013; see Appendix A for full list). This corpus size was selected based on an a priori power analysis (implemented in G*Power 3.1; Faul et al., 2007) examining the number of books needed to identify a medium effect size ($d = .50$; $\alpha = .05$; power $= .80$) in two-tailed *t*-tests comparing two independent and equal-sized groups of books (i.e., books targeting younger and older children). The books included those that were author-illustrated (i.e., the author also produced the illustrations) or collaboratively produced (i.e., separate author and illustrator; see Appendix A for details). Author-illustrated and collaborative picture books did not differ in the key metric of interest (noun-referent co-occurrence; see *Methods* and *Results* sections below), $p = .212$. Accordingly, the current analyses did not distinguish between author-illustrated and collaborative picture books. Sixty-four books in this corpus were designated as "Younger Books", defined as books targeting infants and toddlers between the ages of 0 and 3, while the other 64 books were designated as "Older Books", defined as books targeting preschoolers and young children between the ages of 4 and 8. Each book's age range was determined by consulting the publisher-listed age range in the book itself and the age ranges listed for the book on the sites Amazon and Barnes & Noble.

2.2. Transcription and noun event coding

A team of trained research assistants first transcribed all 128 books. Within each book's transcript, the team then manually tagged all instances of nouns (or "noun events") and the pages in which they occurred. The list of noun events was then reduced to include only events with nouns listed on the MacArthur-Bates Communicative Development Inventory (MCDI; Fenson et al., 1994; see Appendix B). Nouns whose form in the picture books deviated from the form listed on the MCDI (e.g., "mommy" vs. "mom", "cats" vs. "cat") were still included for analysis. In total, the corpus consisted of 3938 noun events to be analyzed across 295 unique noun types (see Table 1 and Appendix B for details). All nouns were then classified as either "First Nouns" or "Early Nouns" based on Wordbank age-of-acquisition norms (see Frank et al., 2021; norms were extracted in July 2023) and following Clerkin and colleagues' (2017) classification scheme: nouns were classified as "First Nouns" if they were reported to be in the receptive vocabularies of at least 50% of infants by 16 months of age; nouns were classified as "Early Nouns" if they were reported to be in the productive vocabularies of at least 50% of toddlers by 30 months of age (see Table 1 for the exact breakdown).

Table 1
Noun events analyzed by book target audience and noun age of acquisition.

	Younger Books ($n = 64$)	Older Books ($n = 64$)
First Nouns		
Total Noun Events	734	1067
Unique Nouns	81	83
Early Nouns		
Total Noun Events	539	1598
Unique Nouns	121	188

Note: Unique Nouns refer to the number of different First and Early Nouns represented in both the Younger and Older Books in this corpus.

2.3. Visual referent coding

2.3.1. Coding of naming page

For each noun event, two trained research assistants coded whether the referent of the noun was visually present in the illustration on the page in which the noun occurred (i.e., the *naming page*). A few coding decisions are worth clarifying this seemingly simple procedure. First, because there is variation in the layout of text and illustrations in picture books, a decision had to be made as to what counts as a page. That is, in some picture books, each single page contains its own text and its own illustration. In other books, both text and illustration span a double-page spread. In yet other books, text may be displayed on one side of a double-page spread while the illustration is displayed on the opposite side of the double-page spread. For the purposes of the current study, in the latter two cases, we treated the double-page spread as the unit of analysis (or the naming "page"). Second, a decision had to be made as to whether the coders' task was to log the visual presence of the referent of the noun *token* or the referent of the noun *type*. That is, in the sentence "But those *shoes* just go, go, go", one could ask whether that specific pair of shoes (noun token) is present in the illustration or whether any pair of shoes (noun type) is present in the illustration. For the purposes of this study, and consistent with how word-referent co-occurrence has been coded in studies of child-directed speech (Bergelson & Aslin, 2017; Clerkin & Smith, 2022), coders logged the visual presence of the noun type (i.e., not restricted to the specific noun token being discussed). Third, coding the visual presence of some nouns (e.g., "morning" in "When I got out of bed this *morning* I tripped on the skateboard") can be especially challenging because their referents may not be something visible. Following how such cases have been dealt with in previous studies that have coded the presence of word referents in child-directed speech (e.g., Bergelson & Swingley, 2013; see Casey et al., 2023), we simply relied on trained coders to use features of the illustration to discern, to the best of their ability, whether the referents of these more abstract nouns were present or not in the illustration. For example, the referent of "morning" would have been coded as visually present on pages that depicted a sunlight-filled sky with characters waking up from sleep. Finally, in cases where a noun was repeated on a page (11.9 % of noun events were repeated on the page), each instance was treated as a separate event.

2.3.2. Coding of non-naming pages and other books

In addition to coding whether the referent of a noun event was visually present on the naming page, coders also logged two other properties for each noun event. First, they coded whether the referent of the noun event was present on pages where the noun did not appear in the text within the same picture book as the noun event (hereafter, *non-naming pages*; see Fig. 2). That is, if the word "dog" was written on pages 4, 9, and 15 in a picture book containing 30 pages, research assistants logged the extent to which a dog was present on pages 1–3, 5–8, 10–14, and 16–30. An analysis of non-naming pages offers a window into the degree to which nouns and their referents are aligned in children's picture books, as well as the visual frequency of referents in children's picture books that mention their labels.

Second, coders logged whether the referent of the noun event was present in a sample of picture books in which the noun was never mentioned in its text (hereafter, *other book pages*; see Fig. 2). Specifically, for each noun event, the coding team identified five randomly selected books (within the current corpus of 128 books) in which that noun did not appear and assessed the extent to which the referent of the target noun was present on each page of these books. Importantly, these five randomly selected books had the same target audience designation (i.e., Younger Books vs. Older Books) as the book from which the noun event was drawn. An analysis of other

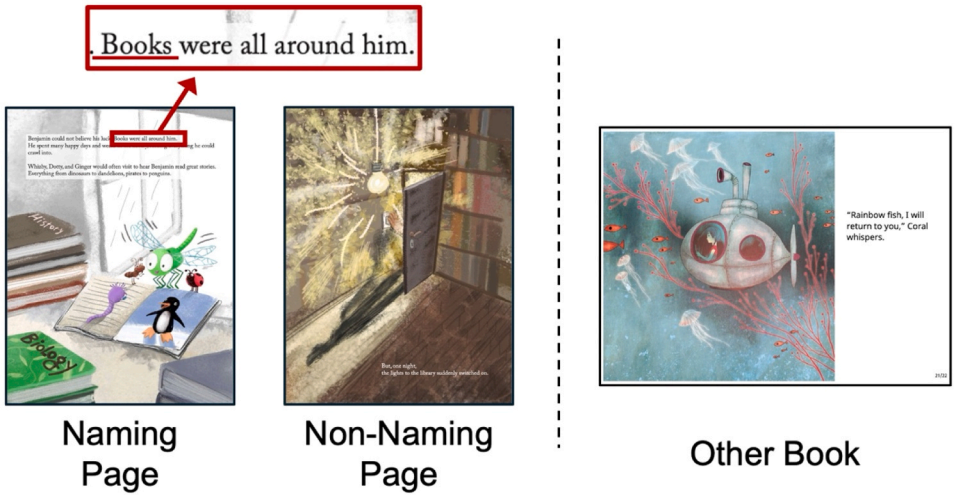


Fig. 2. Illustration of the Three Levels of Visual Referent Coding for Each Noun Event *Note.* Naming Page: pages in the book in which the noun occurred; Non-Naming Page: pages within the same book as the naming page but in which the noun did not occur; Other Book: pages in books in which the noun did not occur. Due to copyright issues, actual book pages used in the current study were not allowed to be used. The illustrations here came from "Books for Benjamin" (de Rouen, 2022) and "The Ocean Dream" (Thuyên, 2012), both of which are released under CC BY 4.0 license.

book pages offers a window into the visual frequency of a noun's referent in children's picture books more generally, beyond those books that explicitly mention the noun. To ensure that sampling five books was sufficient, the coding and analyses were repeated using 25 books for a random sample of forty nouns (20 First Nouns and 20 Early Nouns). The 5-book and 25-book estimates did not differ statistically, $p = .135$, and were strongly correlated, $r(38) = .79$, $p < .001$.

2.4. Coding reliability and data availability

Noun event coding was repeated for a random sampling of 20% of books by a separate team of trained research assistants. Inter-rater reliability between the two coders was high (97.5% agreement; Cohen's kappa: .82). All visual referent coding (naming page, non-naming page, and other books) was completed independently by two members of the coding team. Reliability between two coders for all types of visual referent coding was very high (naming pages: 98.78 % agreement, .97 Cohen's kappa; non-naming pages: 98.5% agreement, .96 Cohen's kappa; other book pages: 99.19% agreement, .96 Cohen's kappa). In the small number of instances where the two coders disagreed, a third coder served as the tiebreaker. The data for this study are openly available on the Open Science Framework repository: https://osf.io/sg98f/?view_only=bc7756a0c79845ab852627a51fad7955

3. Results

3.1. Noun-referent co-occurrences in children's picture books

For each book, we computed the proportion of noun events in which the noun's referent was visually present on the naming page. Mean noun-referent co-occurrence on naming pages was fairly high ($M = .75$; $SD = .21$; see Fig. 3**A**). On average in this corpus of books, about 75% of the time early-learned nouns are mentioned on a picture book's page, their referents are present on that same page. Interestingly, this rate of co-occurrence is in the range of rates reported in studies examining word-referent co-occurrence patterns in child-directed speech (see Bergelson & Swingley, 2013; Clerkin & Smith, 2022). As illustrated in Fig. 3**A**, rates of noun-referent co-occurrence on naming pages was well above rates of referent presence on non-naming pages ($M = .40$; $SD = .23$), $t(127) = 16.12$, $p < .001$, $d = 1.42$, suggesting that the high co-occurrence rates on naming pages are not simply a by-product of the general visual frequency of these referents, but instead the product of the alignment between written noun and drawn referent.

3.2. Temporal dynamics of noun-referent co-occurrence

Fig. 3**B** depicts in more detail the nature of the alignment between the mention of early-learned nouns in the text of picture book pages and the presence of those nouns' referents in the corresponding illustrations. The figure reveals a sharp increase in referent visual presence on the naming page (i.e., page N), with little corresponding change on immediately adjacent pages. Specifically, the likelihood of a noun's visual referent presence increases on average by .31 on page N relative to the page directly before it (i.e., N-1), whereas the increase from page N-2 to page N-1 is only .03. Similarly, noun referent visual presence decreases by .24 from page N to the following page (i.e., N + 1), but only by .05 from page N + 1 to N + 2. Together, these patterns highlight the unique visual properties of naming pages and the tight temporal alignment between written nouns and drawn referents in children's picture books. Fig. 3**B** also reveals a subtle asymmetry in referent visual presence surrounding the naming page, with referents slightly more likely to appear on pages following the naming page (pages N + 1 through N + 5; $M = .46$; $SD = .24$) than on pages preceding it (pages N-5 through N-1; $M = .41$; $SD = .24$), $t(127) = 5.38$, $p < .001$, $d = .48$.

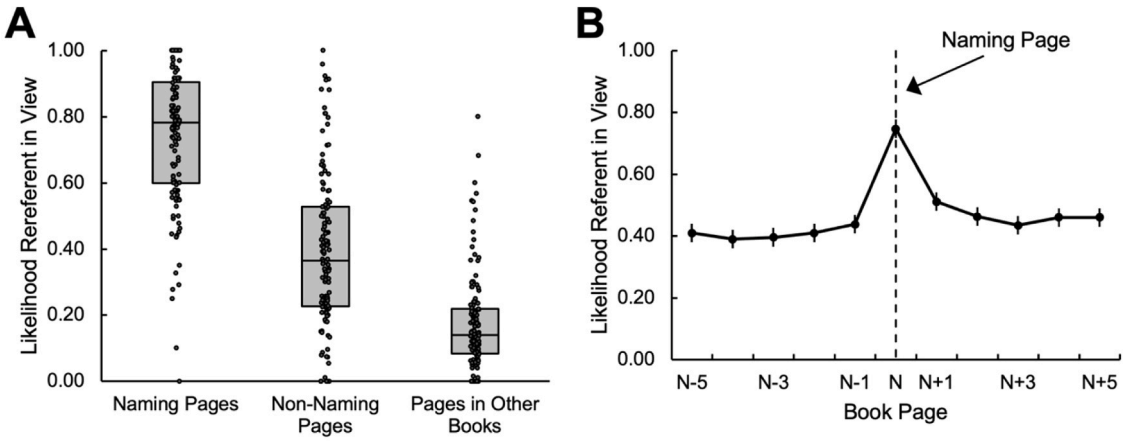


Fig. 3. Noun referent visual presence across page type (A) and around naming page (B) Note. In (A), boxes reflect the interquartile range and horizontal lines represent medians. Each dot represents the average value for a single book; dots are jittered along the horizontal axis to avoid overplotting. In (B), error bars represent standard errors around the mean.

3.3. Referent visual presence in non-naming pages

Although the above analyses suggest that noun-referent co-occurrences in children's picture books are marked by tight temporal alignment, they do not preclude the possibility that the referents of a picture book's nouns are also visually frequent throughout that book. Indeed, in revisiting Fig. 3**A**, it appears that a noun that is mentioned in a picture book has its visual referent present on 40% of pages that did not mention that noun. This rate of visual presence ($M = .40$; $SD = .23$) is much higher than the rate of that noun's visual presence in picture books that do not mention that noun ($M = .18$; $SD = .15$; see Fig. 3**A**), $t(127) = 11.09$, $p < .001$, $d = .98$. This suggests the possibility that the visual world of picture books might also support vocabulary learning by building robust visual representations, a topic we return to in the *General Discussion*.

3.4. Noun referent visual presence as a function of noun age of acquisition

For each book that included both naming and non-naming pages for at least one First Noun and one Early Noun (n = 119), we computed separate visual properties (i.e., noun-referent co-occurrence, referent presence on non-naming pages, and referent presence in other books) for the book's First Nouns and Early Nouns. A 3 (page type) x 2 (noun age of acquisition) analysis of variance (ANOVA) revealed main effects of both page type, $F(2, 236) = 435.17$, $p < .001$, $\eta_p^2 = .79$, and noun age of acquisition, $F(1, 118) = 20.35$, $p < .001$, $\eta_p^2 = .15$, and no interaction between page type and noun age of acquisition, $p = .144$. The main effect of noun age of acquisition highlights that the referents of First Nouns were more likely to be visually present across all page types ($M = .47$; $SD = .19$) than the referents of Early Nouns ($M = .39$; $SD = .14$). Because naming, non-naming, and other book pages index distinct properties, we conducted planned analyses within each page type. Bonferroni-corrected planned comparisons highlight that the age of acquisition effect is especially prominent in non-naming and other book pages. As Fig. 4**A** illustrates, there is little difference between First ($M = .75$; $SD = .24$) and Early Nouns ($M = .71$; $SD = .24$) in noun-referent co-occurrence on naming pages, $t(118) = 1.61$, $p = .110$. In contrast, there is a reliable difference between First ($M = .43$; $SD = .29$) and Early Nouns ($M = .32$; $SD = .22$) in the likelihood of referent visual presence in non-naming pages, $t(118) = 3.44$, $p < .001$, $d = .32$ (see Fig. 4**B**). Similarly, there is a reliable difference between First ($M = .24$; $SD = .21$) and Early Nouns ($M = .14$; $SD = .12$) in the likelihood of referent visual presence in other book pages,

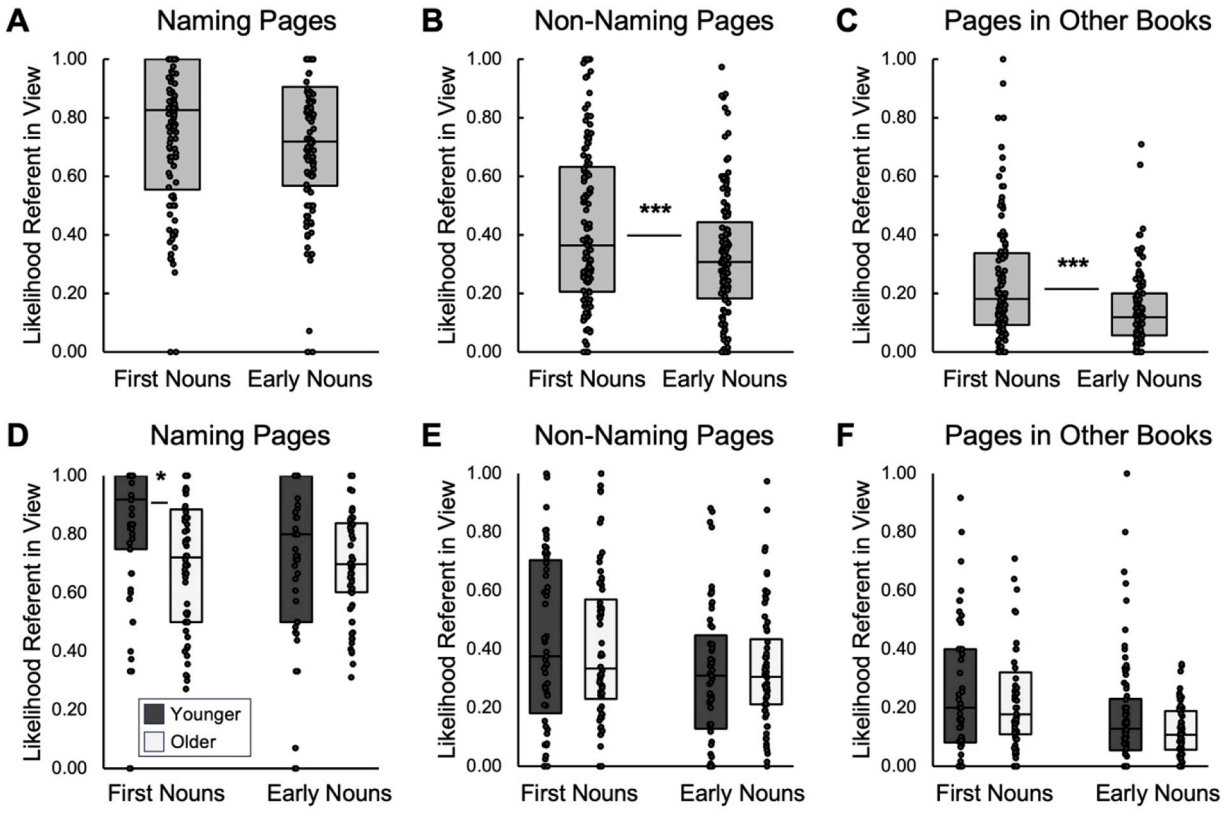


Fig. 4. Noun referent visual presence patterns as a function of noun age of acquisition and book target audience Note. Figures A-C depict noun visual presence across page type as a function of noun age of acquisition (First and Early Nouns). Figures D-F depict noun visual presence across page type as a function of both noun age of acquisition and book target audience (Younger and Older Books). Boxes reflect the interquartile range, and horizontal lines represent medians. Each dot represents the average value for a single book; dots are jittered along the horizontal axis to avoid overplotting. * $p < .05$, ** $p < .01$, *** $p < .001$.

$t(118) = 4.71$, $p < .001$, $d = .43$ (see Fig. 4**C**).

3.5. Noun referent visual presence as a function of book target audience

Fig. 4**D-F** depicts a further decomposition of noun referent visual presence trends as a function of the book's target audience. These data were subjected to a 3 (page type) x 2 (noun age of acquisition) x 2 (book target audience) omnibus ANOVA. The pattern of main effects and interactions involving page type and noun age of acquisition was consistent with that observed in the previous 3 × 2 ANOVA; we therefore focus here only on the effects involving book target audience. This model revealed no main effect of book target audience, $F(1, 117) = 1.22$, $p = .271$, or any two- or three-way interactions involving target audience (smallest $p = .110$). Planned 2 (noun age of acquisition) x 2 (book target audience) analyses within different page types revealed a trend for a main effect of book target audience for naming pages, $F(1, 117) = 2.80$, $p = .097$, $\eta^2_p = .02$, qualified by a marginally significant interaction between noun age of acquisition and book target audience, $F(1, 117) = 3.80$, $p = .054$, $\eta^2_p = .03$. Bonferroni-corrected post-hoc analyses revealed that these trends are explained by a reliable effect of book target audience that was isolated to the naming pages of First Nouns (see Fig. 4**D**). That is, the referents in the naming pages of First Nouns were more likely to be visually present in Younger Books ($M = .81$; $SD = .25$) than in Older Books ($M = .70$; $SD = .22$), $t(117) = 2.52$, $p = .013$, $d = .46$. In contrast, the referents in the naming pages of Early Nouns were equally likely to be visually present in Younger Books ($M = .72$; $SD = .29$) and Older Books ($M = .71$; $SD = .19$), $p = .812$. There were no statistically significant main effects or interactions involving book target audience in the planned analyses of non-naming and other book pages, smallest $p = .282$ (see Fig. 4**E-F**).

4. General discussion

In the current study, we sought to characterize the ways in which nouns and their referents co-occurred in picture books commonly read and heard by English-learning children in North America. The purpose of this work was to add to the recent, and growing, body of research that has sought to document the features of children's picture books as a window into understanding the mechanisms by which they promote early language learning (see Cameron-Faulkner & Noble, 2013; Hsiao et al., 2023; Montag et al., 2015; for review, see Nation et al., 2022). The unique contribution of the current work is in highlighting the visual, as opposed to the linguistic, properties of picture books that may support learning. Our analyses reveal three key findings about these visual properties. First, the visual referents of nouns in picture books are depicted in several ways that are consistent with how visual information bolsters word learning: they co-occur with their nouns at high rates (see Bergelson & Swingley, 2013), they align with their nouns in a temporally precise manner (see Trueswell et al., 2016), and they are visually frequent, including on pages when their nouns are not even mentioned (see Clerkin et al., 2017; Clerkin & Smith, 2022). Second, the visual referents of nouns learned earliest in development, normatively speaking, are unique in their visual properties relative to nouns learned later in development. Finally, although the effects are small, there is a reliable difference in how the visual referents of nouns are depicted in picture books for younger relative to older audiences. Below, we discuss the implications of these findings, before turning to the work's limitations and future directions.

4.1. The visual world of picture books: An optimal input for word learning?

The three visual properties observed in the current study are notable because each has been shown to be effective at promoting word learning. High rates of noun-referent co-occurrence, for example, have been shown to stimulate the process of linking words to their referents in observational (Bergelson & Aslin, 2017; Clerkin & Smith, 2022), experimental (Klein & Yu, 2009; Vouloumanos, 2008), and computational (Kachergis et al., 2017; Yu, 2008) research. Separately, noun-referent temporal alignment has been shown to characterize the most transparent naming events in child-directed speech (Trueswell et al., 2016) and to optimize children's word learning in experimental settings (see de Villiers Rader & Zukow-Goldring, 2010; Gogate & Bahrick, 1998; Whitehurst et al., 1982). Finally, referent visual frequency has recently been shown to be a key ingredient in the development of early object categories (see Clerkin & Smith, 2022; Clerkin et al., 2017; Smith et al., 2018). That is, in a series of studies examining egocentric videos of infants' everyday life, Smith and colleagues observed that referent visual frequency is a prominent feature of the referents of many early-learned nouns (e.g., bottle, chair, spoon). They argue that this visual property is highly compatible with the neural mechanisms of basic learning and memory processes and is therefore ideal for the development of robust object concepts onto which words eventually get mapped.

Although the visual properties identified in the present study are more commonly associated with object name learning and the process of linking words to their referents, these visual properties may also support word learning in other ways. For example, research in the development of biological (Conrad et al., 2020; Gripshover & Markman, 2013; Kelemen et al., 2014), mathematical (Casey et al., 2008; Carrazza & Levine, 2025; van den Heuve-Panhuizen et al., 2016), mechanical (Leech et al., 2020) and socio-emotional (Bergman Deitcher et al., 2021; Schapira & Aram, 2020; Tompkins, 2015) concepts has revealed benefits of shared picture book reading in acquiring domain-specific knowledge. Although these concepts were not the focus of the current work, it is possible that the specific visual properties observed here are indicative of a broader set of visual properties that may underlie those previous findings. Separately, studies have shown how picture books and joint picture book reading support the expansion of children's knowledge about words that they already know (e.g., Ganea et al., 2011; Tare et al., 2010; for review, see Strouse et al., 2018). Although these studies tend to point to the linguistic features of picture books and picture book reading (Gelman et al., 2005; Gelman et al., 2013; Nyhout & O'Neill, 2014; Yu et al., 2025) as the underlying mechanism, it is possible that clear visual depictions of referents in picture books may also play a role in expanding word knowledge (see also Moerk, 1985; Kümmerling-Meibauer & Meibauer, 2013).

Finally, the visual properties observed in the current study may promote word learning by fostering children's broader symbolic development abilities. Children's symbolic capacity is deeply intertwined with word learning (see Cheung et al., 2022; DeLoache, 2004; Namy, 2009), and one symbolic ability particularly relevant to the current context—generalizing and transferring what one learns from picture book illustrations to the real world—has a surprisingly protracted developmental trajectory (for reviews, see Barr, 2013; Ganea & Canfield, 2015). Importantly, research has shown that repeated exposure to picture books boosts children's symbolic learning from picture books (Simcock & DeLoache, 2008; see also Horst et al., 2011). The present finding that picture books contain frequent visual representations of the same referent points to one mechanism by which picture books may support children's symbol development. As illustrated in Fig. 5, this frequency often involves multiple depictions of the same object from different viewpoints across the pages of a single book. We hypothesize that encountering varied perspectives of a single referent in close temporal succession may help children develop rich visual representations of object categories which in turn support mapping labels to those object categories, recognizing novel instances of those categories, and linking illustrations of those categories to their real-world counterparts. Although this hypothesis awaits direct empirical investigation, its plausibility is supported by recent work linking visual object recognition and symbolic understanding (Smith, 2003), object image variability and object name learning (Slone et al., 2019), and observing multiple exemplars to 2D-to-3D generalization (Hartley & Whiteley, 2024).

Based on the literatures above, as well as recent experimental evidence on the effects of visual layout on learning words via picture books (see Flack & Horst, 2018, Weber & Colunga, 2022), we propose that the current work raises the possibility that the visual properties of children's picture books may be a contributing factor to why picture book reading has been linked to advanced vocabulary development. That is, a picture book's visual properties, like those observed here, may help explain why many correlational studies have found reliable associations between frequent picture book reading and rapid vocabulary development (e.g., Farrant & Zubrick, 2012; Raikes et al., 2006; Sénéchal & LeFevre, 2002), why experimental research has revealed young children's facility in learning new words from picture books (e.g., Elley, 1989; Robbins & Ehri, 1994; Sénéchal & Cornell, 1993), and why some interventions have successfully implemented picture book reading programs to boost young children's vocabularies (e.g., Aram & Besser, 2009; Whitehurst et al., 1999). Of course, this proposal in no way conflicts with previously proposed mechanisms, including the unique and valuable linguistic (see Nation et al., 2022) and social (see Reese, 2015) environments that picture book reading cultivates. The current work simply highlights that in addition to these pathways, the visual world of picture books also deserves some attention (see also Kuwabara et al., 2020; Mankovich et al., 2025).

4.2. *Not all noun referents are created equal in their visual properties*

Not all nouns were identical in how their referents were visually depicted in this corpus of picture books. That is, the referents of nouns acquired earliest by American English-learning children were more likely to possess the visual properties known to support word learning. Considering data that positively links both picture book reading (e.g., Farrant & Zubrick, 2012; Robbins & Ehri, 1994; Sénéchal & Cornell, 1993; Whitehurst et al., 1988) and visual referent frequency (see Clerkin et al., 2017; Clerkin & Smith, 2022) with word learning, it may be tempting to consider a possible causal interpretation of these data whereby the way in which certain nouns are depicted in commonly-read children's picture books partly explains why those nouns are acquired early in development. Tempting as this interpretation may be, at least two reasons highlight the need to proceed cautiously with this interpretation. First, most studies that link frequent picture book reading (see Bus et al., 1995; Farrant & Zubrick, 2012; Leech et al., 2022) with early vocabulary

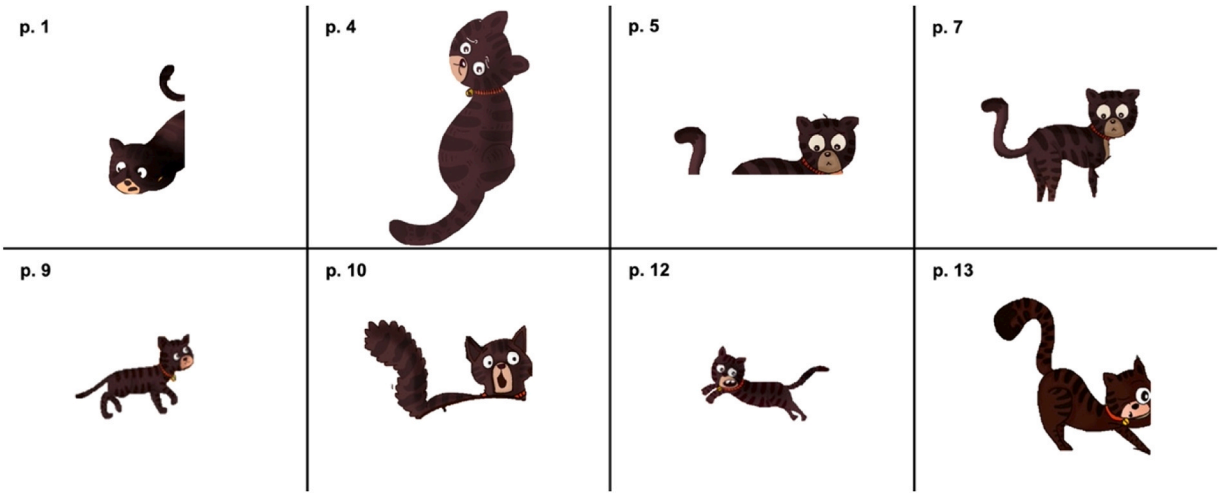


Fig. 5. *An Illustration of a Frequent Visual Object Category across the Pages of a Picture Book Note.* Due to copyright issues, this example does not come from a book used in the current study. These scenes, which come from "Hungry on the Steps" (Nayar, 2018) is released under CC BY 4.0 license and is for illustrative purposes only. The numbers in each cell refer to the page number on which the image was presented. The images were manipulated to only depict the visible parts of the cat and to omit other objects on the page. The cat images are not presented to scale.

development are not specific in whether it is indeed the earliest acquired words whose acquisition is bolstered by picture book reading. Second, and perhaps more persuasively, the kinds of words that are acquired earliest are remarkably consistent across both children and languages (see Frank et al., 2021; Tardif et al., 2008). Considering the variability in early home literacy environments and practices (see Arterberry et al., 2007; Burgess, 2011), we deem it unlikely that one would observe such consistency in acquisition norms if a key driver of those norms were how words are depicted in picture books.

We suggest that the observed correlations between a noun's normative age of acquisition and how their referents are depicted in children's picture books are more likely explained in other ways. One potential explanation is that there is an underlying causal arrow pointing in the opposite direction. That is, perhaps picture book authors and illustrators purposefully depict things that young children already know to provide a familiar anchor that can scaffold their still-developing story comprehension abilities. A different possibility is that a third factor explains the observed correlations. For example, perhaps the kinds of objects that are visually frequent in children's picture books are also the kinds of things that are visually frequent in children's everyday learning experiences, and it is the latter type of visual frequency that drives the age of acquisition norms (see Clerkin et al., 2017; Clerkin & Smith, 2022). Although getting to the bottom of these correlations is a worthwhile future endeavor, it is worth stressing the value of the descriptive data themselves (see also Lewis et al., 2022; Montag et al., 2015; for review, see Nation et al., 2022). That is, regardless of why the data are the way they are, they help paint the picture of what kinds of information are present in young children's picture books. Separately, it is worth noting that the broader argument that the visual properties of referents in children's picture books may be part of the pathway by which picture book reading supports learning does not rest on adopting a narrower argument that the way in which referents of specific words are depicted in picture books is causally linked to the normative age of acquisition of those words.

4.3. Developmental differences (and similarities) in picture books

Our analyses on how the visual world of picture books changes as a function of target audience yielded mixed results, with some analyses (e.g., noun-referent co-occurrence rate of first-learned nouns) revealing small, but reliable, differences but most other analyses revealing no differences. Although the developmental changes may not be as widespread or robust as hypothesized, those that were found were in the predicted direction and in line with the developmental trajectory of children's word learning capabilities. That is, the finding that picture books for younger audiences were more likely to depict nouns and their referents on the same page fit well with the findings that younger word learners rely more heavily on in-the-moment perceptual salience (e.g., see Golinkoff & Hirsh-Pasek, 2006), benefit more from synchronous word-referent presentations (e.g., see Gogate et al., 2001), and struggle more when words are linked to absent referents (e.g., see Ganea & Saylor, 2013). Together with other findings showing by-audience differences in the visual world of picture books (see Kuwabara et al., 2020; Kümmerling-Meibauer & Meibauer, 2013; Mankovich et al., 2025), these results highlight how the input that is cultivated in picture books is tuned, though perhaps coarsely, to the learning constraints of the audience. Considering that even small effects at the level of an individual book can render substantial benefits across repeated reading experiences (see Montag et al., 2015), perhaps this tuning is also part of the mechanism by which picture book reading supports early language learning.

The fact that we found several null developmental effects, as well as small effect sizes where there were developmental differences, raises two issues worth considering in future research. First, the current study's use of publisher recommendations as a measure of audience age range may not accurately characterize the developmental appropriateness of these books (see Çer, 2016; Dwyer & Neuman, 2008) or the actual audience that typically reads these books (see Daniels et al., 2022; Bergman Deitcher et al., 2019; Wagner, 2017). Interestingly, in one study that examined developmental differences in how picture books visually portrayed mental state information, Dyer and colleagues derived their target audience estimates not via publisher suggestions but via guidebooks written by children's literature experts (e.g., Freeman, 1984; for details, see Dyer et al., 2000). In their study, Dyer and colleagues found no difference between their picture books for younger (3- to 4-year-olds) and older (5- to 6-year-olds) children. Thus, future work should explore whether the current developmental findings generalize under different classification schemes of book target audience. Second, as the data in Figs. 3 and 4 highlight, there is greater variability within each of the target audience groups than between them, underscoring a broader trend illustrated by all the data figures in this study: picture books vary tremendously in their visual properties – and likely vary tremendously in other properties. Considering the variability in learning experiences that reading these different books would likely produce, a deeper understanding of both the sources and implications of picture book variability would be an invaluable direction for future research.

4.4. Limitations and future directions

In addition to further research on picture book variability, there are a few other directions that would expand the current work and address some of its shortcomings. First, this study focused exclusively on early-learned nouns. Thus, future work is needed to understand how well the current data generalize to all types of nouns (e.g., late-learned nouns, proper nouns) and to other word categories (e.g., verbs, adjectives). Second, the sample of picture books analyzed in the current study is limited in multiple ways: (1) they mostly belong to the narrative picture book genre, (2) they represent only a sliver of the possible books to which children are exposed (see Hudson Kam & Matthewson, 2017), and (3) they were selected based on their popularity with North American audiences. Thus, future research should examine the extent to which the current data generalize to other picture book genres, to a broader sample of picture books, and to picture books in other cultures and languages. Finally, as with all studies that focus on characterizing the features of children's picture books (e.g., Cameron-Faulkner & Noble, 2013; Dyer et al., 2000; Lewis et al., 2022; Montag et al., 2015; for review see Nation et al., 2022), the current study's goal was to quantify the information available to learners from these picture books.

Although this approach informs us about the structure of the learning environment, as well as how it differs across word and book type, it does not characterize the information that children actually sample and process from picture books. Future work that combines descriptive work like this with studies of children's processing and learning would go a long way to deepen our understanding of children's learning from picture books.

5. Conclusion

Scholars of children's literature have long admired the intricate way in which picture books weave together their text and illustrations to convey engaging stories (for review see Sipe, 2012). The current study was a preliminary attempt to characterize the word learning environment that this interweaving produces. Our results point to an environment, whether by design or not, that is replete with properties known to optimize word learning, suggesting the possibility that the interconnections between their words and illustrations help explain why picture book reading is reliably associated with vocabulary growth. Of course, many gaps must be filled before this possibility is realized. Considering the centrality of picture book illustrations for processes beyond word learning, including grabbing children's attention (Evans & Saint-Aubin, 2005), stimulating caregiver extratextual talk (Nyhout & O'Neill, 2014), eliciting socio-communicative behaviors (Rohlfing et al., 2015), and fostering concept development (Ward et al., 2017) to name a few, we suggest that filling those gaps would be a worthwhile investment.

Author Note

Portions of this research were part of A.M.'s doctoral dissertation submitted to the University of Connecticut. We thank Wilona Boafo, Ariana Bonilla, Audra Lisowicz, Gabrielle Agcaolli, Georgia Falk, Jieun Park, Riley Kunetz, Ethel Dvoskin, Parker Brobson, Aditi Thanker Hemant, and Ava Liosatos for assistance with this project. A special thanks to Raina Becker, Noor Javed, and Natalie Hudak for all their contributions to this project. This research was supported in part by the National Science Foundation (DGE-1747486), a UConn Graduate School Doctoral Dissertation Fellowship, a UConn Presidential Scholars Enrichment Award (to Raina Becker), the James S. McDonnell Foundation (JSMF 220020549), and the National Institutes of Health (R00-HD082358). The authors declare that there is no conflict of interest.

CRediT authorship contribution statement

Suanda Sumarga: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Amanda Mankovich:** Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Appendix A

Picture Book Corpus

Table A1
Picture Books in the Corpus Classified as Younger Books

A is for Awesome!: 23 Iconic Women Who Changed the World by Eva Chen **[a]** & Derek Desierto **[i]**
B is for Bear: A Very First Book for the Baby You Love by Roger Priddy **[a,i]**
Baby Cakes by Karma Wilson **[a]** & Sam Williams **[i]**
Baby Shoes by Dashka Slater **[a]** & Hiroe Nakata **[i]**
Baby Signs: A Baby Sized Introduction to Speaking with Sign Language by Joy Allen **[a,i]**
Banana by Ed Vere **[a,i]**
Barnyard Dance by Sandra Boynton **[a,i]**
Big Girl Panties by Fran Manushkin **[a]** & Valeria Petrone **[i]**
Calm-Down Time by Elizabeth Verdick **[a]** & Marieka Heinlen **[i]**
Clifford the Big Red Dog by Norman Bridwell **[a,i]**
Corduroy by Don Freeman **[a,i]**
Daddy, Papa, and Me by Leslea Newman **[a]** & Carol Thompson **[i]**
Dig by Andrea Zimmerman **[a]** , David Clemesha **[a]** & Marc Rosenthal **[i]**
Dino Potty: Learn to Potty With Dino by Sara Conway **[a]** & Michael Garton **[i]**
Each Peach Pear Plum by Allan Ahlberg **[a,i]** & Janet Ahlberg **[a,i]**
Everyone Poops by Taro Gomi **[a,i]**
Everywhere Babies by Susan Meyers **[a]** & Marla Frazee **[i]**
Five Little Monkeys Jumping on the Bed by Eileen Christelow **[a,i]**
Girl of Mine by Jabari Asim **[a]** & LeUyen Pham **[i]**
Go Get 'Em Tiger by Sabrina Moyle **[a]** & Eunice Moyle **[i]**
Good Night, Biscuit by Alyssa Satin Capucilli **[a]** & Pat Schories **[i]**
Good Night, Gorilla by Peggy Rathmann **[a,i]**
Goodnight, Goodnight Construction Site by Sherri Duskey Rinker **[a]** & Tom Lichtenheld **[i]**

(*continued on next page*)

Table A1 (*continued*)

Grandma's Christmas Wishes by Holly Berry Byrd **[a]** & Jennifer A. Bell **[i]**
Grumpy Bird by Jeremy Tankard **[a,i]**
Grumpy Monkey Says No! by Suzanne Lang **[a]** & Max Lang **[i]**
Hairy Maclary from Donaldson's Dairy by Lynley Dodd **[a,i]**
Hug by Jez Alborough **[a,i]**
I Am Sheriff Woody by Meika Hashimoto **[a]** & RH Disney **[i]**
I Love Colors by Margaret Miller **[a,i]**
I Love You More, Babysaur by Rose Rossner **[a]** & Junissa Bianda **[i]**
I Love You Through and Through by Bernadette Rossetti-Shustak **[a]** & Caroline Jayne Church **[i]**
I Went Walking by Sue Williams **[a]** & Julie Vivas **[i]**
Just a Toy by Gina Mayer **[a]** & Mercer Mayer **[a, i]**
Little Blue Truck by Alice Schertle **[a]** & Jill McElmurry **[i]**
Little Gorilla by Ruth Bornstein **[a,i]**
Llama Llama Nighty-Night by Anna Dewdney **[a,i]**
Love Makes a Family by Sophie Beer **[a,i]**
Love You Forever by Robert N. Munsch **[a]** & Sheila McGraw **[i]**
Make Me Smile by Melanie Joyce **[a]** & Gabi Murphy **[a, i]**
Mama's Pajamas by Mara Van Fleet **[a,i]**
More Blueberries by Susan Musgrave **[a]** & Esperanca Melo **[i]**
Mutt Dog! by Stephen Michael King **[a,i]**
My Body by Jill McDonald **[a,i]**
My New Baby by Rachel Fuller **[a,i]**
Ocean Friends (Touch & Feel) by Jennifer Schiavello **[a,i]**
On the Night You Were Born by Nancy Tillman **[a,i]**
Orange Pear Apple Bear by Emily Gravett **[a,i]**
Pete the Kitty's First Day of Preschool by James Dean **[a,i]** & Kimberly Dean **[a,i]**
Potty by Leslie Patricelli **[a,i]**
Row, Row, Row Your Boat by Annie Kubler **[a,i]**
Sally at the Farm by Stephen Huneck **[a,i]**
Ten Little Fingers and Ten Little Toes by Mem Fox **[a]** & Helen Oxenbury **[i]**
That's Not My Dinosaur by Fiona Watt **[a]** & Rachel Wells **[i]**
The Family Book by Todd Parr **[a,i]**
The Foot Book by Dr. Seuss **[a,i]**
The Itsy Bitsy Spider by Maddie Frost **[a]** & Amy Pixton **[i]**
The Nose Book by Al Perkins **[a]** & Joe Mathieu **[i]**
The Poky Little Puppy by Janette Sebring Lowrey **[a]** & Gustaf Tenggren **[i]**
The Runaway Bunny by Margaret Wise Brown **[a]** & Clement Hurd **[i]**
The Snowy Day by Ezra Jack Keats **[a,i]**
Wash, Wash, Wash by Pamela Chanko **[a]** & Alicia Padron **[i]**
Welcome Little One by Sandra Magsamen **[a,i]**
You're My Little Pumpkin Pie by Nicola Edwards **[a]** & Natalie Marshall **[i]**

Note. [a] marks the author; [i] marks the illustrator; [a,i] marks both the author and illustrator

Table A2
Picture Books in the Corpus Classified as Older Books

A Sick Day for Amos McGee by Philip C. Stead **[a]** & Erin E. Stead **[i]**
Airplanes: Soaring! Diving! Turning! by Patricia Hubbell **[a]** , Megan Halsey **[i]** , & Sean Addy **[i]**
Alexander and the Terrible, Horrible, No Good, Very Bad Day by Judith Viorst **[a]** & Ray Cruz **[i]**
Barney and Baby Bop go to School by Mark S. Bernthal **[a]** & Dennis Full **[i]**
Bear Wants More by Karma Wilson **[a]** & Jane Chapman **[i]**
Bunny Party by Rosemary Wells **[a,i]**
Busiest Firefighters Ever! by Richard Scarry **[a,i]**
Caps for Sale by Esphyr Slobodkina **[a,i]**
Charlie and the New Baby by Ree Drummond **[a]** & Diane deGroat **[i]**
Chrysanthemum by Kevin Henkes **[a,i]**
Click, Clack, Moo: Cows that Type by Doreen Cronin **[a]** & Betsy Lewin **[i]**
Clifford at the Circus by Norman Bridwell **[a,i]**
Cloudy With a Chance of Meatballs by Judi Barrett **[a]** & Ron Barrett **[i]**
Don't Eat Bees: Life Lessons from Chip the Dog by Devorah Petty **[a]** & Mike Boldt **[i]**
Eating the Alphabet by Lois Ehlert **[a,i]**
Elmer by David McKee **[a,i]**
Fancy Nancy by Jane O'Connor **[a]** & Robin Preiss Glasser **[i]**
Froggy Goes to Bed by Jonathan London **[a]** & Frank Remkiewicz **[i]**
From Head to Toe by Eric Carle **[a,i]**
Goldilicious by Victoria Kann **[a,i]**
Goodnight Moon by Margaret Wise Brown **[a]** & Clement Hurd **[i]**
Harry the Dirty Dog by Gene Zion **[a]** & Margaret Bloy Graham **[i]**
How to Catch a Star by Oliver Jeffers **[a,i]**
I Choose to Try Again by Elizabeth Estrada **[a,i]**
I Just Forgot by Mercer Mayer **[a,i]**

(*continued on next page*)

Table A2 (*continued*)

I Want my Hat Back by Jon Klassen **[a,i]**
I'm Not Scared, You're Scared by Seth Meyers **[a]** & Rob Sayegh Jr. **[i]**
I'm a Big Sister by Joanna Cole **[a]** & Rosalinda Kightley **[i]**
If You Give a Mouse a Cookie by Laura Joffe Numeroff **[a]** & Felicia Bond **[i]**
Jamberry by Bruce Degen **[a,i]**
Knuffle Bunny: A Cautionary Tale by Mo Willems **[a,i]**
Ladybug Girl at the Beach by David Soman & Jacky Davis **[a]**
Little Blue Truck Leads the Way by Alice Schertle **[a]** & Jill McElmurry **[i]**
Nigel and The Moon by Antwan Eady **[a]** & Gracey Zhang **[i]**
No, David! by David Shannon **[a,i]**
Oh, the Thinks You Can Think! by Dr. Seuss **[a,i]**
Olivia by Ian Falconer **[a,i]**
Pete the Cat: I Love My White Shoes by James Dean **[i]** & Eric Litwin **[a]**
Show Dog by Megan McCarthy **[a,i]**
Shrek! by William Steig **[a,i]**
Six Dinner Sid by Inga Moore **[a,i]**
Skeleton Meets the Mummy by Steve Metzger **[a]** & Aaron Zenz **[i]**
The Berenstain Bears Forget Their Manners by Stan Berenstain **[a,i]** & Jan Berenstain **[a,i]**
The Carrot Seed by Ruth Krauss **[a]** & Crockett Johnson **[i]**
The Day the Crayons Quit by Drew Daywalt **[a]** & Oliver Jeffers **[i]**
The Gentle Bulldozer by Amy Baron **[a]** & Rogério Coelho **[i]**
The Gruffalo by Julia Donaldson **[a]** & Axel Scheffler **[i]**
The Happiest Kid by Sarah Bagley Steele **[a]**, Elsa Pui Si Lo **[i]** & Clarice Yunyi Cai **[i]**
The Hello, Goodbye Window by Norton Juster **[a]** & Chris Raschka **[i]**
The Little Engine That Could by Watty Piper **[a]**, George Hauman **[i]** & Doris Hauman **[i]**
The Napping House by Audrey Wood **[a]** & Don Wood **[i]**
The Other Side by Jacqueline Woodson **[a]** & E. B. Lewis **[i]**
The Pocket Chaotic by Ziggy Hanaor **[a]** & Daniel Gray-Barnett **[i]**
The Polar Express by Chris Van Allsburg **[a,i]**
The Pout-Pout Fish by Deborah Diesen **[a]** & Dan Hanna **[i]**
The School of Failure: A Story About Success by Rosie J Pova **[a]** & Monika Filipina **[i]**
The True Story of the 3 Little Pigs! by Jon Scieszka **[a]** & Lane Smith **[i]**
Thumbelina by Hans Christian Andersen **[a]** & Brad Sneed **[i]**
Train by Elisha Cooper **[a,i]**
Trashy Town by Andrea Zimmerman **[a]**, David Clemesha **[a]** & Dan Yaccarino **[i]**
When Dinosaurs Came with Everything by Elise Broach **[a]** & David Small **[i]**
Where the Wild Things Are by Maurice Sendak **[a,i]**
Wherever You Are My Love Will Find You by Nancy Tillman **[a,i]**
Winter Days in the Big Woods by Laura Ingalls Wilder **[a]** & Renée Graef **[i]**

Note. [a] marks the author; [i] marks the illustrator; [a,i] marks both the author and illustrator

Appendix B

Nouns Appearing in this Corpus

Table B1
List and Frequencies of the First Nouns in this Corpus

airplane [1, 25]	car [0, 6]	grandma [8, 13]	peekaboo [1, 12]
apple [7, 6]	cat [3, 9]	grandpa [12, 23]	phone [4, 4]
arm [12, 3]	cereal [0, 6]	hair [12, 5]	play [3, 10]
baby [71, 18]	chair [2, 0]	hand [6, 20]	puppy [28, 89]
ball [1, 11]	cheese [4, 16]	hat [5, 27]	shoe [3, 5]
balloon [2, 3]	cookie [15, 0]	head [61, 14]	sleep [0, 4]
banana [0, 12]	cow [5, 27]	home [0, 1]	sock [21, 10]
bath [13, 2]	cry [9, 19]	hug [3, 24]	splash [3, 20]
bathroom [6, 13]	cup [1, 1]	juice [1, 7]	spoon [13, 5]
bathtub [1, 3]	dad [3, 12]	key [12, 24]	stair [2, 0]
bed [2, 2]	dance [0, 4]	kiss [6, 5]	stroller [1, 0]
bedroom [1, 0]	diaper [3, 5]	kitchen [4, 3]	table [1, 1]
bellybutton [33, 50]	dinner [5, 16]	kitten [21, 19]	teacher [0, 5]
bird [0, 1]	dog [2, 0]	look [2, 26]	toe [3, 0]
bite [4, 0]	door [1, 9]	lunch [16, 23]	tooth [30, 3]
blanket [28, 22]	drink [26, 29]	milk [21, 48]	toy [20, 23]
block [1, 12]	duck [3, 1]	mom [28, 6]	truck [1, 1]
book [3, 0]	ear [9, 1]	mouth [1, 4]	tummy [1, 4]
bottle [2, 16]	eye [7, 27]	nap [0, 3]	tv [5, 22]
bread [2, 6]	finger [25, 45]	nose [0, 4]	walk [1, 1]

(*continued on next page*)

Table B1 (*continued*)

breakfast [0, 2]	fish [8, 31]	outside [7, 8]	water [1, 1]
brush [15, 4]	food [1, 0]	pajamas [0, 6]	
bubble [8, 15]	foot [6, 6]	pants [4, 2]	
bunny [1, 5]	fork [9, 27]	patacake [1, 4]	

Note. The two numbers in brackets reflect the frequency of each noun in the Younger Books and Older Books corpus respectively

Table B2
List and Frequencies of the Early Nouns in this Corpus

animal [14, 13]	drawer [1, 1]	monkey [16, 14]	shoulder [3, 3]
aunt [2, 0]	dress [2, 2]	moon [5, 22]	shovel [0, 1]
back [0, 2]	egg [0, 7]	morning [10, 40]	shower [0, 2]
backyard [0, 4]	elephant [5, 31]	mouse [3, 50]	sink [0, 6]
basket [0, 1]	face [3, 16]	movie [0, 1]	sister [8, 22]
beach [0, 9]	fall [0, 1]	muffin [1, 0]	sky [9, 23]
bean [0, 3]	farm [1, 4]	napkin [0, 2]	slide [0, 1]
bear [22, 74]	fit [0, 1]	necklace [0, 1]	slipper [0, 1]
bee [0, 8]	flag [0, 3]	night [17, 37]	smile [2, 7]
bicycle [0, 1]	flower [3, 28]	noise [1, 2]	snack [4, 5]
blue [1, 1]	friend [15, 58]	nut [0, 2]	snow [10, 10]
boat [3, 6]	frog [2, 1]	orange [5, 3]	snowman [1, 0]
boot [2, 2]	game [3, 3]	oven [1, 1]	soap [2, 3]
bowl [1, 3]	garage [0, 1]	owl [1, 10]	soup [0, 3]
box [1, 13]	garden [4, 9]	pancake [1, 5]	star [4, 23]
boy [9, 28]	giraffe [2, 2]	paper [1, 7]	stick [3, 5]
broom [0, 1]	girl [8, 43]	park [1, 4]	store [9, 4]
brother [5, 15]	glass [0, 10]	party [0, 7]	story [4, 20]
bucket [0, 1]	glasses [3, 1]	pea [1, 4]	stove [0, 1]
bug [1, 1]	glove [0, 4]	peanut butter [0, 2]	strawberry [2, 3]
bus [3, 9]	goose [2, 0]	pen [0, 3]	street [4, 17]
butt [2, 0]	grape [0, 2]	pencil [1, 2]	sun [6, 25]
butter [0, 4]	grass [8, 4]	penguin [0, 6]	sweater [1, 3]
butterfly [1, 2]	green [0, 3]	people [3, 20]	swing [0, 2]
button [7, 2]	hamburger [0, 2]	picture [0, 20]	taste [0, 1]
cake [2, 14]	helicopter [0, 3]	pig [4, 13]	this little piggy [1, 0]
can [1, 12]	help [0, 8]	pillow [0, 5]	tiger [1, 2]
candy [1, 2]	horse [12, 4]	pizza [0, 2]	toast [0, 4]
carrot [2, 4]	hose [0, 3]	plant [1, 3]	today [6, 8]
chalk [1, 0]	house [12, 71]	plate [0, 2]	tomorrow [4, 3]
cheek [4, 0]	ice [0, 1]	playground [1, 2]	tongue [1, 4]
chicken [3, 1]	ice cream [1, 7]	pool [2, 1]	toothbrush [0, 1]
chin [3, 2]	inside [3, 4]	potato [0, 5]	top [1, 0]
clock [0, 4]	jump [1, 0]	potty [3, 1]	towel [0, 1]
closet [0, 3]	knee [2, 7]	present [2, 3]	train [2, 68]
cloud [0, 33]	knife [0, 1]	pumpkin [0, 3]	trash [0, 2]
coat [0, 1]	knock [0, 1]	push [1, 1]	tree [10, 23]
coffee [0, 1]	lady [4, 6]	puzzle [0, 2]	turkey [1, 1]
cold [0, 2]	lamb [0, 1]	rain [5, 10]	turtle [0, 1]
comb [0, 3]	lamp [2, 0]	red [0, 1]	uncle [1, 0]
cook [0, 1]	leg [6, 9]	refrigerator [1, 6]	watch [1, 3]
corn [0, 4]	light [8, 12]	ride [1, 1]	wind [7, 8]
couch [0, 1]	lion [3, 1]	rock [9, 5]	window [4, 25]
crayon [1, 8]	lip [2, 2]	roof [1, 9]	wolf [0, 11]
dark [1, 2]	lollypop [0, 1]	room [7, 13]	work [5, 11]
day [54, 101]	love [17, 10]	sandwich [0, 2]	yard [0, 4]
dish [0, 3]	man [2, 6]	school [4, 28]	yellow [0, 1]
doctor [10, 2]	meat [0, 2]	shake [0, 1]	zebra [1, 0]
doll [3, 17]	melon [0, 1]	share [0, 1]	zoo [7, 4]
donkey [1, 6]	mitten [0, 2]	sheep [6, 0]	
doughnut [0, 4]	money [0, 2]	shorts [0, 1]	

Note. The two numbers in brackets reflect the frequency of each noun in the Younger Books and Older Books corpus respectively

Data availability

Data is hosted on OSF, and a link has been provided

References

Aram, D., & Besser, S. (2009). Early literacy interventions: Which activities to include? At what age to start? And who will implement them? *Journal for the Study of Education and Development, 32*(2), 171–187. https://doi.org/10.1174/021037009788001806

Arterberry, M. E., Midgett, C., Putnick, D. L., & Bornstein, M. H. (2007). Early attention and literacy experiences predict adaptive communication. *First Language, 27*(2), 175–189. https://doi.org/10.1177/0142723706075784

Baldwin, D. A. (1993). Early referential understanding: Infants' ability to recognize referential acts for what they are. *Developmental Psychology, 29*(5), 832–843. https://doi.org/10.1037/0012-1649.29.5.832

Barr, R. (2013). Memory constraints on infant learning from picture books, television, and touchscreens. *Child Development Perspectives, 7*(4), 205–210. https://doi.org/10.1111/cdep.12041

Bergelson, E., & Aslin, R. N. (2017). Nature and origins of the lexicon in 6-mo-olds. *Proceedings of the National Academy of Sciences of the United States of America, 114*(49), 12916–12921. https://doi.org/10.1073/pnas.1712966114

Bergelson, E., & Swingley, D. (2013). The acquisition of abstract words by young infants. *Cognition, 127*(3), 391–397. https://doi.org/10.1016/j.cognition.2013.02.011

Bergman Deitcher, D., Aram, D., & Adar, G. (2019). Book selection for shared reading: Parents' considerations and researchers' views. *Journal of Early Childhood Literacy, 19*(3), 291–315. https://doi.org/10.1177/1468798417718236

Bergman Deitcher, D., Aram, D., Khalaily-Shahadi, M., & Dwairy, M. (2021). Promoting preschoolers' mental-emotional conceptualization and social understanding: A shared book-reading study. *Early Education and Development, 32*(4), 501–515. https://doi.org/10.1080/10409289.2020.1772662

Burgess, S. R. (2011). Home literacy environments (HLEs) provided to very young children. *Early Child Development and Care, 181*(4), 445–462. https://doi.org/10.1080/03004430903450384

Bus, A. G., van IJzendoorn, M. H., & Pellegrini, A. D. (1995). Joint book reading makes for success in learning to read: A meta-analysis on intergenerational transmission of literacy. *Review of Educational Research, 65*(1), 1–21. https://doi.org/10.2307/1170476

Cameron-Faulkner, T., & Noble, C. (2013). A comparison of book text and child directed speech. *First Language, 33*(3), 268–279. https://doi.org/10.1177/0142723713487613

Carney, R. N., & Levin, J. R. (2002). Pictorial illustrations still improve students' learning from text. *Educational Psychology Review, 14*(1), 5–26. https://doi.org/10.1023/A:1013176309260

Carrazza, C., & Levine, S. C. (2025). Less is not always more: Rich and meaningful counting books lead to greater gains in number understanding than sparse counting books. *Developmental Psychology, 61*(3), 446–460. https://doi.org/10.1037/dev0001826

Casey, B., Erkut, S., Ceder, I., & Young, J. M. (2008). Use of a storytelling context to improve girls' and boys' geometry skills in kindergarten. *Journal of Applied Developmental Psychology, 29*(1), 29–48. https://doi.org/10.1016/j.appdev.2007.10.005

Casey, K., Potter, C. E., Lew-Williams, C., & Wojcik, E. H. (2023). Moving beyond "nouns in the lab": Using naturalistic data to understand why infants' first words include *uh-oh* and *hi*. *Developmental Psychology, 59*(11), 2162–2173. https://doi.org/10.1037/dev0001630

Çer, E. (2016). Preparing books for children from birth to age six: The approach of appropriateness for the child. *Journal of Education and Practice, 7*(6), 78–99.

Cheung, R. W., Hartley, C., & Monaghan, P. (2022). Receptive and expressive language ability differentially support symbolic understanding over time: Picture comprehension in late talking and typically developing children (Article) *Journal of Experimental Child Psychology, 214*, Article 105305. https://doi.org/10.1016/j.jecp.2021.105305.

Chiong, C., & DeLoache, J. S. (2013). Learning the ABCs: What kinds of picture books facilitate young children's learning? *Journal of Early Childhood Literacy, 13*(2), 225–241. https://doi.org/10.1177/1468798411430091

Clerkin, E. M., Hart, E., Rehg, J. M., Yu, C., & Smith, L. B. (2017). Real-world visual statistics and infants' first-learned object names. *Philosophical Transactions of the Royal Society B: Biological Sciences, 372*, Article 20160055. https://doi.org/10.1098/rstb.2016.0055

Clerkin, E. M., & Smith, L. B. (2022). Real-world statistics at two timescales and a mechanism for infant learning of object names. *Proceedings of the National Academy of Sciences, 119*(18), Article e2123239119. https://doi.org/10.1073/pnas.2123239119

Conrad, M., Kim, E., Blacker, K. A., Walden, Z., & LoBue, V. (2020). Using storybooks to teach children about illness transmission and promote adaptive health behavior–A pilot study (Article) *Frontiers in Psychology, 11*, 942. https://doi.org/10.3389/fpsyg.2020.00942.

Daniels, D., Salley, B., Walker, C., & Bridges, M. (2022). Parent book choices: How do parents select books to share with infants and toddlers with language impairment? *Journal of Early Childhood Literacy, 22*(2), 279–307. https://doi.org/10.1177/1468798420985668

de Rouen, R. G. (2022). *Books for Benjamin*. R. G. de Rouen, LLC.

de Villiers Rader, N., & Zukow-Goldring, P. (2010). How the hands control attention during early word learning. *Gesture, 10*(2-3), 202–221. https://doi.org/10.1075/gest.10.2–3.05 rad

DeLoache, J. S. (2004). Becoming symbol-minded. *Trends in Cognitive Sciences, 8*(2), 66–70. https://doi.org/10.1016/j.tics.2003.12.004

Dickinson, D. K., Griffith, J. A., Golinkoff, R. M., & Hirsh-Pasek, K. (2012). How reading books fosters language development around the world. *Child Development Research, 2012*, 1–15. https://doi.org/10.1155/2012/602807

Dwyer, J., & Neuman, S. B. (2008). Selecting books for children birth through four: A developmental approach. *Early Childhood Education Journal, 35*, 489–494. https://doi.org/10.1007/s10643-008-0236-5

Dyer, J. R., Shatz, M., & Wellman, H. M. (2000). Young children's storybooks as a source of mental state information. *Cognitive Development, 15*(1), 17–37. https://doi.org/10.1016/S0885-2014(00)00017-4

Dziemianko, A. (2022). The usefulness of graphic illustrations in online dictionaries. *ReCALL: Journal of Eurocall, 34*(2), 218–234. https://doi.org/10.1017/S0958344021000264

Elia, I., van den Heuvel-Panhuizen, M., & Georgiou, A. (2010). The role of pictures in picture books on children's cognitive engagement with mathematics. *European Early Childhood Education Research Journal, 18*(3), 275–297. https://doi.org/10.1080/1350293X.2010.500054

Elley, W. B. (1989). Vocabulary acquisition from listening to stories. *Reading Research Quarterly, 24*(2), 174–187. https://doi.org/10.2307/747863

Evans, M. A., & Saint-Aubin, J. (2005). What children are looking at during shared storybook reading: Evidence from eye movement monitoring. *Psychological Science, 16*(11), 913–920. https://doi.org/10.1111/j.1467-9280.2005.01636.x

Farrant, B. M., & Zubrick, S. R. (2012). Early vocabulary development: The importance of joint attention and parent-child book reading. *First Language, 32*(3), 343–364. https://doi.org/10.1177/0142723711422626

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191. https://doi.org/10.3758/BF03193146

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., Tomasello, M., Mervis, C. B., & Stiles, J. (1994). Variability in early communicative development. v–173 *Monographs of the Society for Research in Child Development, 59*(5). https://doi.org/10.2307/1166093.

Flack, Z. M., Field, A. P., & Horst, J. S. (2018). The effects of shared storybook reading on word learning: A meta-analysis. *Developmental Psychology, 54*(7), 1334–1346. https://doi.org/10.1037/dev0000512

Flack, Z. M., & Horst, J. S. (2018). Two sides to every story: Children learn words better from one storybook page at a time. *Infant and Child Development, 27*(1), Article e2047. https://doi.org/10.1002/icd.2047

Frank, M. C., Braginsky, M., Yurovsky, D., & Marchman, V. A. (2021). *Variability and consistency in early language learning: The Wordbank project*. The MIT Press. https://doi.org/10.7551/mitpress/11577.001.0001

Freeman, L. (1984). *Books kids will sit for: A guide for using children's literature for librarians, teachers, and parents*. Allyside Press.

Ganea, P. A., & Canfield, C. F. (2015). An examination of factors that affect young children's learning and transfer from picturebooks. In. In B. Kümmerling-Meibauer, J. Meibauer, K. Nachtigäller, & K. J. Rohlfing (Eds.), *Learning from picturebooks: Perspectives from child development and literacy studies* (pp. 33–50). Routledge.

Ganea, P. A., Ma, L., & DeLoache, J. S. (2011). Young children's learning and transfer of biological information from picture books to real animals. *Child Development, 82*(5), 1421–1433. https://doi.org/10.1111/j.1467-8624.2011.01612.x
Ganea, P. A., Pickard, M. B., & DeLoache, J. S. (2008). Transfer between picture books and the real world by very young children. *Journal of Cognition and Development, 9*(1), 46–66. https://doi.org/10.1080/15248370701836592
Ganea, P. A., & Saylor, M. M. (2013). Representational constraints on language development: Thinking and learning about absent things. *Child Development Perspectives, 7*(4), 227–231. https://doi.org/10.1111/cdep.12045
Garner, P. W., & Parker, T. S. (2018). Young children's picture-books as a forum for the socialization of emotion. *Journal of Early Childhood Research, 16*(3), 291–304. https://doi.org/10.1177/1476718X18775760
Gelman, S. A., Chesnick, R. J., & Waxman, S. R. (2005). Mother-child conversations about pictures and objects: Referring to categories and individuals. *Child Development, 76*(6), 1129–1143. https://doi.org/10.1111/j.1467-8624.2005.00876.x-i1
Gelman, S. A., Ware, E. A., Manczak, E. M., & Graham, S. A. (2013). Children's sensitivity to the knowledge expressed in pedagogical and nonpedagogical contexts. *Developmental Psychology, 49*(3), 491–504. https://doi.org/10.1037/a0027901
Gleitman, L. R., Cassidy, K., Nappa, R., Papafragou, A., & Trueswell, J. C. (2005). Hard words. *Language Learning and Development, 1*(1), 23–64. https://doi.org/10.1207/s15473341lld0101_4
Gogate, L. J., & Bahrick, L. (1998). Intersensory redundancy facilitates learning of arbitrary relations between vowel sounds and objects in seven-month-old infants. *Journal of Experimental Child Psychology, 69*(2), 133–149. https://doi.org/10.1006/jecp.1998.2438
Gogate, L. J., Walker-Andrews, A. S., & Bahrick, L. E. (2001). The intersensory origins of word comprehension: An ecological–dynamic systems view. *Developmental Science, 4*(1), 1–18. https://doi.org/10.1111/1467-7687.00143
Golinkoff, R. M., Can, D. D., Soderstrom, M., & Hirsh-Pasek, K. (2015). Baby)talk to me: The social context of infant-directed speech and its effects on early language acquisition. *Current Directions in Psychological Science, 24*(5), 339–344. https://doi.org/10.1177/0963721415595345
Golinkoff, R. M., & Hirsh-Pasek, K. (2006). Baby wordsmith: From associationist to social sophisticate. *Current Directions in Psychological Science, 15*(1), 30–33. https://doi.org/10.1111/j.0963-7214.2006.00401.x
Gripshover, S. J., & Markman, E. M. (2013). Teaching young children a theory of nutrition: Conceptual change and the potential for increased vegetable consumption. *Psychological Science, 24*(8), 1541–1553. https://doi.org/10.1177/0956797612474827
Hartley, C., & Whiteley, H. A. (2024). Do multiple exemplars promote preschool children's retention and generalisation of words learned from pictures? *Cognitive Development, 70*, Article 101459. https://doi.org/10.1016/j.cogdev.2024.101459
Horst, J. S., & Houston-Price, C. (2015). An open book: What and how young children learn from picture and story books. *Frontiers in Psychology, 6*, 1719. https://doi.org/10.3389/fpsyg.2015.01719
Horst, J. S., Parsons, K. L., & Bryan, N. M. (2011). Get the story straight: Contextual repetition promotes word learning from storybooks. Article 17. *Frontiers in Psychology, 2*. https://doi.org/10.3389/fpsyg.2011.00017
Hsiao, Y., Dawson, N. J., Banerji, N., & Nation, K. (2023). The nature and frequency of relative clauses in the language children hear and the language children read: A developmental cross-corpus analysis of English complex grammar. *Journal of Child Language, 50*(3), 555–580. https://doi.org/10.1017/S0305000921000957
Hudson Kam, C. L., & Matthewson, L. (2017). Introducing the infant bookreading database (IBDb). *Journal of Child Language, 44*(6), 1289–1308. https://doi.org/10.1017/S0305000916000490
Justice, L. M., Skibbe, L., Canning, A., & Lankford, C. (2005). Pre-schoolers, print and storybooks: An observational study using eye movement analysis. *Journal of Research in Reading, 28*(3), 229–243. https://doi.org/10.1111/j.1467-9817.2005.00267.x
Kachergis, G., Yu, C., & Shiffrin, R. M. (2017). A bootstrapping model of frequency and context effects in word learning. *Cognitive Science, 41*(3), 590–622. https://doi.org/10.1111/cogs.12353
Kelemen, D., Emmons, N. A., Seston Schillaci, R., & Ganea, P. A. (2014). Young children can be taught basic natural selection using a picture-storybook intervention. *Psychological Science, 25*(4), 893–902. https://doi.org/10.1177/0956797613516009
Klein, K., & Yu, C. (2009). Joint or conditional probability in statistical word learning: Why decide? In In. N. Taatgen, H. van Rijn, L. Schomaker, & J. Nerbonne (Eds.), *Proceedings of the 31st annual meeting of the cognitive science society* (pp. 3105–3110). Amsterdam, Netherlands: Cognitive Science Society.
Kucker, S. C., & Samuelson, L. K. (2012). The first slow step: Differential effects of object and word-form familiarization on retention of fast-mapped words. *Infancy, 17*(3), 295–323. https://doi.org/10.1111/j.1532-7078.2011.00081.x
Kümmerling-Meibauer, B., & Meibauer, J. (2013). Towards a cognitive theory of picturebooks. *International Research in Children's Literature, 6*(2), 143–160. https://doi.org/10.3366/ircl.2013.0095
Kümmerling-Meibauer, B., & Meibauer, J. (2015). Picturebooks and early literacy: How do picturebooks support early conceptual and narrative development? In. In B. Kümmerling-Meibauer, J. Meibauer, K. Nachtigäller, & K. J. Rohlfing (Eds.), *Learning from picturebooks: Perspectives from child development and literacy studies* (pp. 13–32). Routledge.
Kuwabara, M., Alonso, J., & Ayala, D. (2020). Cultural differences in visual contents in picture books (Article) *Frontiers in Psychology, 11*, 304. https://doi.org/10.3389/fpsyg.2020.00304.
Lany, J., Aguero, A., & Thompson, A. (2022). The temporal dynamics of labelling shape infant object recognition. *Infant Behavior Development, 67*, 1–14. https://doi.org/10.1016/j.infbeh.2022.101698
Leech, K. A., Haber, A. S., Jalkh, Y., & Corriveau, K. H. (2020). Embedding scientific explanations into storybooks impacts children's scientific discourse and learning (Article) *Frontiers in Psychology, 11*, 1016. https://doi.org/10.3389/fpsyg.2020.01016.
Leech, K. A., McNally, S., Daly, M., & Corriveau, K. H. (2022). Unique effects of book-reading at 9-months on vocabulary development at 36-months: Insights from a nationally representative sample of Irish families. *Early Childhood Research Quarterly, 58*, 242–253. https://doi.org/10.1016/j.ecresq.2021.09.009
Lewis, M., Cooper Borkenhagen, M., Converse, E., Lupyan, G., & Seidenberg, M. S. (2022). What might books be teaching young children about gender? *Psychological Science, 33*(1), 33–47. https://doi.org/10.1177/09567976211024643
Mankovich, A., MacDonald, S., Kinnie, B., Johnson, S. C., & Suanda, S. H. (2025). Information sources for word meaning in children's picture books: A human simulation paradigm study. *Journal of Cognition and Development, 26*, 90–110. https://doi.org/10.1080/15248372.2024.2395515
Marriott, S. (2002). Red in tooth and claw? Images of nature in modern picture books. *Children's Literature in Education, 33*, 175–183. https://doi.org/10.1023/A:1019677931406
Martinez, M., & Harmon, J. M. (2012). Picture/text relationships: An investigation of literary elements in picturebooks. *Literacy Research and Instruction, 51*(4), 323–343. https://doi.org/10.1080/19388071.2012.695856
Masur, E. F. (1982). Mothers' responses to infants' object-related gestures: Influences on lexical development. *Journal of Child Language, 9*(1), 23–30. https://doi.org/10.1017/S0305000900003585
Moerk, E. L. (1985). Picture-book reading by mothers and young children and its impact upon language development. *Journal of Pragmatics, 9*(4), 547–566. https://doi.org/10.1016/0378-2166(85)90021-9
Montag, J. L., Jones, M. N., & Smith, L. B. (2015). The words children hear: Picture books and the statistics for language learning. *Psychological Science, 26*(9), 1489–1496. https://doi.org/10.1177/0956797615594361
Namy, L. L. (2009). Early word learning and other seemingly symbolic behaviors. In In. A. Woodward, & A. Needham (Eds.), *Learning and the infant mind* (pp. 249–262). Oxford University Press.
Nation, K., Dawson, N. J., & Hsiao, Y. (2022). Book language and its implications for children's language, literacy, and development. *Current Directions in Psychological Science, 31*(4), 375–380. https://doi.org/10.1177/09637214221103264
Nayar, N. (2018). *Hungry on the Steps*. Pratham Books.
Nikolajeva, M., & Scott, C. (2001). *How picturebooks work*. Garland.
Noble, C., Sala, G., Peter, M., Lingwood, J., Rowland, C., Gobet, F., & Pine, J. (2019). The impact of shared book reading on children's language skills: A meta-analysis (Article) *Educational Research Review, 28*, Article 100290. https://doi.org/10.1016/j.edurev.2019.100290.

Nodelman, P. (1988). *Words about pictures: The narrative art of children's picture books*. University of Georgia Press.
Nomikou, I., Koke, M., & Rohlfing, K. J. (2017). Verbs in mothers' input to six-month-olds: Synchrony between presentation, meaning, and actions is related to later verb acquisition. *Brain Sciences, 7*(5), 52. https://doi.org/10.3390/brainsci7050052
Nyhout, A., & O'Neill, D. K. (2014). Storybooks aren't just for fun: Narrative and non-narrative picture books foster equal amounts of generic language during mother-toddler book sharing (Article) *Frontiers in Psychology, 5*, 325. https://doi.org/10.3389/fpsyg.2014.00325.
Pereira, A. F., Smith, L. B., & Yu, C. (2014). A bottom-up view of toddler word learning. *Psychonomic Bulletin Review, 21*(1), 178–185. https://doi.org/10.3758/s13423-013-0466-4
Perry, L. K., Custode, S. A., Fasano, R. M., Gonzalez, B. M., & Valtierra, A. M. (2022). Coordination of caregiver naming and children's exploration of solid objects and nonsolid substances. *Frontiers in Psychology, 13*, Article 945664. https://doi.org/10.3389/fpsyg.2022.945664
Pusey, E. B. (1907). *The Confessions of St Augustine*. J.M. Dent & Sons Ltd.
Raikes, H., Luze, G., Brooks-Gunn, J., Raikes, H. A., Pan, B. A., Tamis-LeMonda, C. S., Constantine, J., Tarullo, L. B., & Rodriguez, E. T. (2006). Mother-child bookreading in low-income families: Correlates and outcomes during the first three years of life. *Child Development, 77*(4), 924–953. https://doi.org/10.1111/j.1467-8624.2006.00911.x
Reese, E. (2015). What good is a picturebook? Developing children's oral language and literacy through shared picturebook reading. In. In B. Kümmerling-Meibauer, J. Meibauer, K. Nachtigäller, & K. J. Rohlfing (Eds.), *Learning from picturebooks: Perspectives from child development and literacy studies* (pp. 194–208). Routledge.
Robbins, C., & Ehri, L. C. (1994). Reading storybooks to kindergartners helps them learn new vocabulary words. *Journal of Educational Psychology, 86*(1), 54–64. https://doi.org/10.1037/0022-0663.86.1.54
Rohlfing, K. J., Grimminger, A., & Nachtigäller, K. (2015). Gesturing in joint book reading. In. In B. Kümmerling-Meibauer, J. Meibauer, K. Nachtigäller, & K. J. Rohlfing (Eds.), *Learning from picturebooks: Perspectives from child development and literacy studies* (pp. 99–116). Routledge.
Roth, P. L. (1987). Temporal characteristics of maternal verbal styles. In. In K. E. Nelson, & A. van Kleeck (Eds.), *Children's language: Volume 6* (pp. 137–158). Psychology Press. https://doi.org/10.4324/9781315792668-6.
Rowe, M. L., & Snow, C. E. (2020). Analyzing input quality along three dimensions: Interactive, linguistic, and conceptual. *Journal of Child Language, 47*(1), 5–21. https://doi.org/10.1017/S0305000919000655
Schapira, R., & Aram, D. (2020). Shared book reading at home and preschoolers' socio-emotional competence. *Early Education and Development, 31*(6), 819–837. https://doi.org/10.1080/10409289.2019.1692624
Schwarcz, J. H. (1982). *Ways of the illustrator: Visual communication in children's literature*. Chicago, IL: American Library Association.
Sénéchal, M., & Cornell, E. H. (1993). Vocabulary acquisition through shared reading experiences. *Reading Research Quarterly, 28*(4), 360–374. https://doi.org/10.2307/747933
Sénéchal, M., & LeFevre, J.-A. (2002). Parental involvement in the development of children's reading skill: A five-year longitudinal study. *Child Development, 73*(2), 445–460. https://doi.org/10.1111/1467-8624.00417
Simcock, G., & DeLoache, J. S. (2008). The effect of repetition on infants' imitation from picture books varying in iconicity. *Infancy, 13*(6), 687–697. https://doi.org/10.1080/15250000802459102
Sipe, L. R. (2012). Revisiting the relationships between text and pictures. *Children's Literature in Education, 43*, 4–21. https://doi.org/10.1007/s10583-011-9153-0
Slone, L. K., Smith, L. B., & Yu, C. (2019). Self-generated variability in object images predicts vocabulary growth. *Developmental Science, 22*(6), Article e12816. https://doi.org/10.1111/desc.12816
Smith, L. B. (2003). Learning to recognize objects. *Psychological Science, 14*(3), 244–250. https://doi.org/10.1111/1467-9280.03439
Smith, L. B., Jayaraman, S., Clerkin, E., & Yu, C. (2018). The developing infant creates a curriculum for statistical learning. *Trends in Cognitive Sciences, 22*(4), 325–336. https://doi.org/10.1016/j.tics.2018.02.004
Smith, L., & Yu, C. (2008). Infants rapidly learn word-referent mappings via cross-situational statistics. *Cognition, 106*(3), 1558–1568. https://doi.org/10.1016/j.cognition.2007.06.010
Snedeker, J., & Gleitman, L.R. (2004). Why It Is hard to label our concepts. {C}In.D.G. Hall & S.R. Waxman (Eds{C}.), *Weaving a lexicon* (pp. 257–293). Boston Review.
Strouse, G. A., Nyhout, A., & Ganea, P. A. (2018). The role of book features in young children's transfer of information from picture books to real-world contexts (Article) *Frontiers in Psychology, 9*, 50. https://doi.org/10.3389/fpsyg.2018.00050.
Suanda, S. H., Barnhart, M., Smith, L. B., & Yu, C. (2019). The signal in the noise: The visual ecology of parents' object naming. *Infancy, 24*(3), 455–476. https://doi.org/10.1111/infa.12278
Suanda, S. H., Mugwanya, N., & Namy, L. L. (2014). Cross-situational statistical word learning in young children. *Journal of Experimental Child Psychology, 126*, 395–411. https://doi.org/10.1016/j.jecp.2014.06.003
Tamis-LeMonda, C. S., Kuchirko, Y., & Song, L. (2014). Why is infant language learning facilitated by parental responsiveness? *Current Directions in Psychological Science, 23*(2), 121–126. https://doi.org/10.1177/0963721414522813
Tardif, T., Fletcher, P., Liang, W., Zhang, Z., Kaciroti, N., & Marchman, V. A. (2008). Baby's first 10 words. *Developmental Psychology, 44*(4), 929–938. https://doi.org/10.1037/0012-1649.44.4.929
Tare, M., Chiong, C., Ganea, P., & DeLoache, J. (2010). Less is more: How manipulative features affect children's learning from picture books. *Journal of Applied Developmental Psychology, 31*(5), 395–400. https://doi.org/10.1016/j.appdev.2010.06.005
Tomasello, M., & Barton, M. E. (1994). Learning words in nonostensive contexts. *Developmental Psychology, 30*(5), 639–650. https://doi.org/10.1037/0012-1649.30.5.639
Tompkins, V. (2015). Mothers' cognitive state talk during shared book reading and children's later false belief understanding. *Cognitive Development, 36*, 40–51. https://doi.org/10.1016/j.cogdev.2015.08.004
Trueswell, J. C., Lin, Y., Armstrong, B. I. I. I., Cartmill, E. A., Goldin-Meadow, S., & Gleitman, L. R. (2016). Perceiving referential intent: Dynamics of reference in natural parent–child interactions. *Cognition, 148*, 117–135. https://doi.org/10.1016/j.cognition.2015.11.002
van den Heuvel-Panhuizen, M., Elia, I., & Robitzsch, A. (2016). Effects of reading picture books on kindergartners' mathematics performance. *Educational Psychology, 36*(2), 323–346. https://doi.org/10.1080/01443410.2014.963029
Vlach, H. A., & Johnson, S. P. (2013). Memory constraints on infants' cross-situational statistical learning. *Cognition, 127*(3), 375–382. https://doi.org/10.1016/j.cognition.2013.02.015
Vong, W. K., Wang, W., Orhan, A. E., & Lake, B. M. (2024). Grounded language acquisition through the eyes and ears of a single child. *Science, 383*(6682), 1–8. https://doi.org/10.1126/science.adi1374
Vouloumanos, A. (2008). Fine-grained sensitivity to statistical information in adult word learning. *Cognition, 107*(2), 729–742. https://doi.org/10.1016/j.cognition.2007.08.007
Vouloumanos, A., & Werker, J. F. (2009). Infants' learning of novel words in a stochastic environment. *Developmental Psychology, 45*(6), 1611–1617. https://doi.org/10.1037/a0016134
Wagner, L. (2013). By the numbers: A quantitative content analysis of children's picturebooks. Article 850. *Frontiers in Psychology, 4*. https://doi.org/10.3389/fpsyg.2013.00850
Wagner, L. (2017). Factors influencing parents' preferences and parents' perceptions of child preferences of picturebooks (Article) *Frontiers in Psychology, 8*, 1448. https://doi.org/10.3389/fpsyg.2017.01448.
Ward, J. M., Mazzocco, M. M., Bock, A. M., & Prokes, N. A. (2017). Are content and structural features of counting books aligned with research on numeracy development? *Early Childhood Research Quarterly, 39*, 47–63. https://doi.org/10.1016/j.ecresq.2016.10.002
Weber, J., & Colunga, E. (2022). Learning from word books: Does the type of illustration matter? In. J. Culbertson, A. Perfors, H. Rabagliati, & V. Ramenzoni (Eds.), Proceedings of the 44th Annual Conference of the Cognitive Science Society (pp. 1434-1440)..

Weisberg, D. S., Ilgaz, H., Hirsh-Pasek, K., Golinkoff, R., Nicolopoulou, A., & Dickinson, D. K. (2015). Shovels and swords: How realistic and fantastical themes affect children's word learning. *Cognitive Development, 35*, 1–14. https://doi.org/10.1016/j.cogdev.2014.11.001

Wellman, H. M., Hollander, M., & Schult, C. A. (1996). Young children's understanding of thought bubbles and of thoughts. *Child Development, 67*(3), 768–788. https://doi.org/10.2307/1131860

West, K. L., Fletcher, K. K., Adolph, K. E., & Tamis-LeMonda, C. S. (2022). Mothers talk about infants' actions: How verbs correspond to infants' real-time behavior. *Developmental Psychology, 58*(3), 405–416. https://doi.org/10.1037/dev0001285

Whitehurst, G. J., Falco, F. L., Lonigan, C. J., Fischel, J. E., DeBaryshe, B. D., Valdez-Menchaca, M. C., & Caulfield, M. (1988). Accelerating language development through picture book reading. *Developmental Psychology, 24*(4), 552–559. https://doi.org/10.1037/0012-1649.24.4.552

Whitehurst, G. J., Kedesdy, J., & White, T. G. (1982). A functional analysis of meaning. In S. Kuczaj II (Ed.). *Language development volume 1: Syntax and semantics* (pp. 397–427). Lawrence Erlbaum Associates.

Whitehurst, G. J., Zevenbergen, A. A., Crone, D. A., Schultz, M. D., Velting, O. N., & Fischel, J. E. (1999). Outcomes of an emergent literacy intervention from head start through second grade. *Journal of Educational Psychology, 91*(2), 261–272. https://doi.org/10.1037/0022-0663.91.2.261

Yaden, D. B., Smolkin, L. B., & Conlon, A. (1989). Preschoolers' questions about pictures, print conventions, and story text during reading aloud at home. *Reading Research Quarterly, 24*(2), 188–214. https://doi.org/10.2307/747864

Yu, C. (2008). A statistical associative account of vocabulary growth in early word learning. *Language Learning and Development, 4*(1), 32–62. https://doi.org/10.1080/15475440701739353

Yu, C., & Smith, L. B. (2012). Embodied attention and word learning by toddlers. *Cognition, 125*(2), 244–262. https://doi.org/10.1016/j.cognition.2012.06.016

Yu, S., Tan, A., Zhang, S., Miao, P., Carlson, R., Tobias, G., & Rose, D. (2025). Generics revisited: Analyzing generalizations in children's books and caregivers' speech. In In. A. Ruggeri, D. Barner, C. Walker, & N. Bramley (Eds.), *Proceedings of the 47th annual conference of the cognitive science society*. San Francisco, CA: Cognitive Science Society.

Further reading

Suanda, S. H., Smith, L. B., & Yu, C. (2016). The multisensory nature of verbal discourse in parent–toddler interactions. *Developmental Neuropsychology, 41*(5-8), 324–341. https://doi.org/10.1080/87565641.2016.1256403