A novel corpus of naturalistic picture book reading with 2 to 3 year old children

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Abstract: Substantial literature suggests that reading to children is positively associated with language outcomes, but the causal pathways are less well understood. One possibility is that reading to children promotes language input that is particularly useful for some aspects of language learning. To better understand the language that is produced during picture book reading, we built a sharable corpus of caregiver-child interactions during book reading recorded in homes. Caregivers overwhelmingly read the book text. However, books varied in the language they generated, with some books promoting more conversational turns and extra-textual language, while others promoted more overall words, unique words, and longer utterances. Relative to other conversational contexts, books generally generated overall more words, more lexically diverse talk, and longer utterances. We see different profiles of language generated during book reading that are all plausibly linked with language skills. If a causal pathway exists between shared book reading and language outcomes, a sensible candidate may be that reading provides a varied range of linguistic experiences.

Keywords: Naturalistic language environments; Picture book reading; lexical diversity; Syntactic complexity.

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Introduction

Caregivers often read to young children, including those who cannot yet read themselves. This behaviour, called shared book reading, is common in many, but not all, households and cultures around the world. Advice that caregivers should read to children is everywhere, particularly in western societies, where reading to children is popularly associated with a range of benefits.

The recommendation to read to children is not only in the popular culture; there is in fact substantial literature suggesting that reading to children is positively associated with language outcomes. Research has shown positive effects of book reading on a wide range of early language skills, including child's receptive and expressive language skills (e.g. Arterberry, et al., 2007; Demir-Lira, et al., 2019; Farrant & Zubrick, 2011; Fletcher & Reese, 2005; Karrass & Braungart- Rieker, 2005; Mol & Newman, 2014; Ninio, 1983; Payne, et al., 1994; Senechal & LeFevre, 2002) and subsequent literacy skills (e.g. Bus, et al., 1995; Deckner, et al., 2006; Dickinson & Tabors, 1991; Lonigan, et al., 2000; Scarborough, et al., 1991; Shahaeian et al., 2018). While scientific studies of reading have correlated exposure to picture books with positive language development outcomes, the causal pathways are less well understood. For recommendations surrounding reading to children to be in line with the scientific evidence, we must better understand the pathways by which reading to young children comes to be associated with improved language outcomes.

The goal of this study is to build a corpus of parent-child interactions during book reading sessions recorded in homes. We quantify features of the language that appears in these recordings, with an emphasis on understanding the independent contributions of caregiver-child conversation and book text read aloud. With this information, we can begin to understand the linguistic experiences that book reading may provide that might plausibly explain the associations with positive language outcomes.

One of the important reasons to better understand the unique linguistic (or other) experiences that shared book reading may provide is to establish whether there is a plausible pathway between shared book reading and language outcomes at all. Many studies fail to replicate the language-boosting effects of picture book reading, find only small effects (Davies et al., 2020; Noble et al., 2020; Noble et al., 2019; Sala & Gobet, 2017; Simons et al., 2016) or note problems with the generalizability of existing findings to lower-income or other marginalized families (Manz et al., 2010; Mol et al., 2008). One potential explanation is that correlations between shared book reading and language outcomes may reflect other factors that are causally independent of book reading. For example, caregivers who read more often to children are more likely to be white and tend to be wealthier than those who read less frequently

(Bradley, et al., 2001; Raikes et al., 2006; Yarosz & Barnett, 2001; Young, et al., 1998), so the effects of book reading on language outcomes may be attributable to other factors. We must remain open to the null hypothesis that the positive language outcomes might in fact be associated with the numerous other benefits that wealth and status impart on children. An investigation of the effect of shared book reading proper on language outcomes requires that the field have clearer explanations for why more frequent book reading might be associated with positive language outcomes.

When caregivers read to young children, interactions are not limited to simply reading the text of the book; caregivers and children engage in conversation as well. Caregivers may point to and label pictures, paraphrase text, comment and expand upon the text, ask and answer questions, and engage in other extra-textual speech (Deckner et al., 2006; Fletcher, et al., 2008; Kam & Matthewson, 2017; Ninio & Bruner, 1978; Whitehurst et al., 1988; see Read, et al., 2023 for a recent review). This conversation is often investigated as a source or language input for young children that is particularly useful for language learning (Demir-Lira, et al., 2019; Fletcher & Reese, 2005; Fletcher, et al., 2008; Hindman, et al., 2014; Justice & Ezell, 2000; Mol et al., 2008; Muhinyi & Rowe, 2019). One of the most highly investigated features of caregiver-child conversation during shared book reading is that it tends to contain more conversational turn-taking than other contexts of child-caregiver speech (Gilkerson et al., 2017; Sosa, 2016). A large research literature has identified frequent back-and-forth conversational turn taking, as a type of linguistic experience that is positively associated with language outcomes (Donnelly & Kidd, 2021; Gilkerson et al., 2018; Romeo et al., 2018), and shared book reading may be a particularly dense source of these conversational turns (Gilkerson et al., 2017). In addition to being a source of conversational turns, the speech itself may consist of more unique words and longer sentences (Crain-Thoreson, et al., 2001; Hoff-Ginsberg, 1991; Muhinyi, et al., 2020; Whitehurst et al., 1988) than other caregiver-child activities, such as free-play (Gilkerson et al., 2017; Sosa, 2016). The spontaneous conversation produced during shared book reading may contain many features that make it particularly useful for language learning.

Following the hypothesis that shared book reading may promote caregiver-child conversation, many interventions that aim to use shared book reading to improve language outcomes frequently target extra-textual talk. These interventions include dialogic reading, in which caregivers are encouraged to ask open-ended questions during book reading that encourage children to verbally respond so that the child becomes a more active participant in the book reading activity (Arnold, et al., 1994; Whitehurst et al., 1988). During dialogic reading, caregivers are instructed to use language that aims to elicit speech from children, i.e. rephrasing child's utterances with same/different voice or sentence structure, and asking open-ended questions, which are features of caregiver speech that have been shown to support child language development in other conversational contexts (Baker & Nelson, 1984; Cleave et al., 2015;

Farrar, 1990; Girolametto & Weitzman, 2002; Huttenlocher et al., 2010; Nelson, 1977). Dialogic reading is associated with gains in expressive language skills (Chacko et al., 2018; Lonigan & Whitehurst, 1998; Valdez- Menchaca & Whitehurst, 1992; Whitehurst, et al., 1994; Whitehurst et al., 1999), perhaps more than other reading methods (Flack, et al., 2018). Caregiver-child conversation may be a particularly useful source of language input, and if it is indeed associated with shared book reading, may indicate a plausible pathway by which book reading comes to be positively associated with language outcomes.

Another hypothesized pathway by which shared book reading may influence language outcomes is through exposure to the book text itself. When caregivers read aloud the text of picture books, they may be exposing children to unique words and sentences, including complex syntax, that might otherwise be rare. Picture books are well established to be more lexically diverse than other types of linguistic input that children may encounter. For example, picture books contain more unique words than child-directed speech (Hayes & Ahrens, 1988; Massaro, 2015, 2017; Montag et al., 2015). In line with these findings, recordings of caregivers and children interacting in book reading contexts indicate that linguistic input from shared book reading may be more lexically sophisticated than that of other contexts (Crain-Thoreson, et al., 2001; Salo, et al., 2016; Sosa, 2016; Weizman & Snow, 2001). However, these studies do not explicitly distinguish between book text read aloud and extra-textual talk, so the increase in lexical diversity could be attributed to book text read aloud or to other sources of speech, for example, labelling or talking about pictures.

In addition to the inventories of words, the text of picture books contains more instances of complex sentence structure than other sources of child-directed or child-available (speech that is produced in the vicinity of the child even if it may not be explicitly child-directed) speech. Studies that compare syntactic constructions present in picture books and child-directed speech find that picture books contain a variety of language structures that are rare in typical child-directed speech. For example, Cameron-Faulkner and Noble (2013) compared syntactic constructions from 20 best-selling picture books in the UK with a sample of British English child directed speech. Picture books contained more complete sentences (e.g. The boy ate a doughnut; The bat is flying) than child-directed speech, which tended to contain more fragments (e.g. on the table), commands (e.g. put it down), and copulas (e.g. It's very heavy; That's nice). The authors suggested that the picture book language could be an important input source for the development of both common linguistic constructions but also complex constructions that might be rare in child-directed speech. Likewise, Montag (2019) focused on American English and compared the frequencies of a set of complex syntactic constructions in a corpus of 100 picture books with a sample of child-directed speech from the CHILDES corpus (MacWhinney, 2000). The text in picture books had significantly higher frequencies of complex syntactic constructions

including passive sentences and sentences containing relative clauses than child-directed speech. Similarly, Hsiao, Dawson, Banerji and Nation (2022) found that complex sentences such as those containing relative clauses are more frequent in child-directed written than spoken corpora, and that frequencies increased as the target age of the child increased. Such findings suggest that picture books could affect language development outcomes by exposing children to types of complex language that might be otherwise sparse in the child-directed input.

To complicate an investigation of the language input that picture books provide, picture books vary wildly in types of stories they tell, and the linguistic and visual formats in which they tell these stories. There is no reason that all books might provide similar linguistic input, or even vary from other sources of child-directed speech along similar dimensions. Different books promote different profiles of language input as a consequence of the story's genre and plot complexity (Price, et al., 2009; Leech & Rowe, 2014; Muhinyi et al., 2019; Read, et al., 2014; Saracho, 2017). Given the enormous variability across picture books, there may not be a single profile of book reading talk, but rather different types of books may promote different profiles of speech. For example, book genre such as fiction versus non-fiction books tend to elicit different profiles of speech from caregivers and children, with non-fiction books often eliciting more frequent and more lexically complex extra-text utterances (Anderson et al, 2004; Price et al., 2009, Weitzman & Snow, 2001). Likewise, Muhinyi et al. (2019) found that complex stories with false beliefs central to the plot elicited longer and more lexically complex caregiver utterances. Book format seems to matter as well, with wordless picture eliciting more caregiver-child conversation (Senechal, Cornell & Broda, 1995) and chapter books (versus picture books) eliciting less extra-text discussion from children (Leech & Rowe, 2014). In an entirely different vein, Read and colleagues (2014) found that caregivers' prosody varied when reading a rhymed than a non-rhymed version of the same animal story. Understanding variability across book types is necessary for developing a more complete picture of the language generated during shared book reading.

To better understand the language generated during naturalistic home book reading, how this input might be different from other sources of child-directed speech, and how this input might vary based on features of the book being read, we created a corpus of recordings of picture book reading sessions made by families in their own homes. We provided parents with 4 books that varied in the amount of text they contained and the syntactic complexity of that text. The full transcripts are available to other researchers as a book reading corpus through the CHILDES online repository (https://childes.talkbank.org/access/Eng-NA/StoopsMontag.html).

We first describe features of the language generated during book reading, and how different books elicited different profiles of speech. Specifically, we expect that

different books should generate different profiles of child and caregiver speech, with some books generating more back-and-forth conversation and others more silent listening of the books. We then compare the language input generated during home book reading sessions with other sources of child-directed speech for age-matched children to understand similarities and differences across shared book reading and other contexts of child-directed speech. In line with other studies of shared book reading, we expect quantitative differences in various aspects of the speech generated during picture book reading and other conversational contexts.

Method

Participants

Families were recruited from the area surrounding the University of Illinois, Urbana-Champaign. The study was approved by the Institutional Review Board and all families gave their informed consent prior to the inclusion in the study.

Caregivers. Twelve families participated in the study. Family demographic information is included in Table 1. For all families, English was the primary language spoken in the home, Education is reported for 24 caregivers because all 12 families were two-parent households.

Table 1. ***Parent demographics***

Demographic Categories	Count or Mean (range)	
Race:	Both Parents White	7
	Both Parents Asian	3
	Asian-White	2
Education:	PhD	6
	MA	5
	BA	7
	AS	6
Income:	$200,000+	1
	$100,000-$200,000	4
	$75,000-$100,000	4
	$25,000-$75,000	3
# children's books at home:	150 (50-200)	
# non-children's books at home:	200 (50-1000)	

Children. The average age of the 12 children included in the study was 31 months (range: 27-37mo; 7 girls, 5 boys). The mean parent reported MLU computed from the MBCDI was 8.3 (range: 3.6-12) and the average MBCDI score was 486 (range 56-675). One child was diagnosed with speech delays and had been receiving speech therapy.

Materials

Four books were selected that varied along two dimensions: Book length, as quantified by the number of words in the book text, and the syntactic complexity of the book, as indexed by the number of a subset of rare sentence types: passive sentences and sentences containing relative clauses. Word counts ranged from 125 words, a book with a few words or one-to-two sentences every few pages, to 1211 words, a more complex narrative book with 4 or more sentences on each page. Rare or complex sentence counts ranged from 0-15. Word counts and rare/complex construction counts are shown in Table 2, as well as the number of reading sessions recorded of each book across all families. Examples of each complex sentence type are shown in Table 3. Audio recordings were made with the OLYMPUS VN-541PC digital audio recorder.

Table 2. ***New Book Summary***

Book Title	Word Count	Count of Complex Syntactic Constructions				# Recordings	# Families
		Subject Relative Clause	Object Relative Clause	Oblique Relative Clause	Passive Main Clause		
That is Not a Good Idea (Mo Willems)	125	0	0	0	0	21	10
When Dinosaurs Came with Everything (Elise Broach)	1018	0	1	1	0	18	10
Stellaluna (Janell Cannon)	1211	2	1	0	0	12	8
Oh the Places You'll Go! (Dr. Seuss)	939	5	4	4	2	9	8

Table 3. ***Syntactic Complexity Summary***

Syntactic Construction	Example
Subject Relative Clause:	More bats gathered around to see the strange young bat **who behaved like a bird**. (from "Stellaluna")
Object Relative Clause:	**The next thing I knew**, she had him cleaning the gutters (from "When dinosaurs came with everything")
Oblique Relative Clause:	**The places you'll go**!; You will come to a place where the streets are not marked. (from "Oh the places you'll go!")
Passive Main Clause:	**You'll be left in a Lurch** (from "Oh the places you'll go!")

Caregivers were asked to select three out of the four books that they did not own that their child was not familiar with, i.e., they have not read to their child before. Caregivers were asked to choose three books because we expected some families would have familiarity with some of the books and we wanted to keep the number of books constant across families. Further, we wanted to keep the recording demands on the families more reasonable with three versus four books. In addition to these three books, families were asked to also record themselves reading books they already owned at home. Families provided a total of 183 individual book reading episodes: 60 of novel books and 123 episodes of books that the family already owned.

The present report focuses on the descriptions and analyses of the 60 recordings (about 10 hours) of the novel books provided to the families. Novel book recordings were not equally distributed across books or families (Table 2) as some families contributed more or longer recordings than others (see Table 5).

Procedure

One parent from each family came to the lab for a one-time pre-study visit during which they were provided with the study materials. Parents selected three books that they did not own from the four available books. Families were provided with a digital recorder which they were instructed to keep at home for two weeks and record a minimum of 6 home-book reading sessions that included the books provided by the lab along with additional sessions including books that they owned at home. Families were not given any instructions about how to read or interact with the books aside from the experimenters emphasizing that the families should read the books the same way as they typically do at home. Experimenters instructed families on how to use the

audio recorder and told families to keep the recorder in a pocket, or someplace not visible during recording. Families were instructed to record the first reading of the new books. After completing the recordings, families were instructed to return the digital recorder with the recorded reading sessions at the end of the two-week period via the postal mail service in a pre-paid envelope. During the visit, each parent completed 2 questionnaires: a paper-and-pencil MBCDI Words and Sentences and a brief survey of home reading practices.

Compensation. Families were given travel expense reimbursements, $40 compensation for the time taken to record book-reading sessions at home and kept the 3 books they selected during the visit to the lab.

Audio transcription and coding

Coding. 12 trained undergraduate research assistants used the ELAN software (Brugman & Russel, 2004) to diarize (tag speakers), segment (identify timestamp boundaries of utterances), and transcribe approximately 10 hours (575 minutes = 9.58 hours) of picture book reading of the four new books provided by the researchers. Additionally, each transcript was checked for accuracy by a research assistant who did not transcribe that file, so each research assistant transcribed some files and acted as a checker on other files. Transcription and annotation were done in the ACLEW DAS format (Casillas et al., 2017; Soderstrom et al., 2021), which is compatible with the CHAT and CLAN systems, with a few exceptions. First, we did not code vocal maturity (vcm) of child utterances because all target children produced words. Second, we included an additional tier under the adult speaker tier in which we coded whether utterances consisted of book text read aloud or other speech. Each minute of audio took about an hour to transcribe, and an additional half hour to check, yielding what we believe is an accurate and thorough corpus of naturalistic home book reading. The raw audio and transcripts will be available to other researchers in the CHILDES repository (https://childes.talkbank.org/). All other data and code is available at https://osf.io/b3egw/.

Measurements. Book text that was read aloud, and all speech produced by any individual captured in the audio recording was transcribed, including sibling and off-topic speech when present (e.g., cases when another speaker entered the room and asked something not related to the book reading session). From these transcripts, turn-taking, word counts per minute, counts of unique words uttered, and mean length of utterance (in words) of caregiver and child utterances were computed. In addition to computing overall counts for caregiver speech, we computed these variables of interest separately for caregiver speech consisting of book text read aloud or extra-textual speech.

We defined extra-textual speech as any caregiver speech (not sibling speech) produced during book reading that was not book text read aloud. However, adult speech not directed to the target child was not included. For example, if a caregiver entered the room and asked a question, and the picture-book-reading caregiver responded, none of this speech was included in our counts, though it was transcribed. The speech we defined as extra-textual includes talk about the stories or pictures, as well as talk not directly related to the story (e.g., instructions to turn the page, requests to sit down) or occasional talk unrelated to book reading. The amount of talk not directly related to the book content varied by family.

We computed the mean length of an utterance (in words) as an approximate measure of the grammatical complexity of an utterance (Hunt, 1970; Parker & Brorson, 2005). A segment was considered an utterance if it satisfied at least two out of three of the following criteria: (a) there is a silence/speech pause equal or longer than 2 seconds before it, (b) it presented terminal intonation contour, and (c) it presented syntax that makes a complete sentence (Bernstein & Brundage, 2013). Those cases that presented ambiguities were discussed by the first and last authors until a consensus was reached. The mean length of utterances was calculated by dividing the total number of words produced by a speaker by the total number of utterances produced by a speaker using a python script (see Supplemental Materials). The mean length of utterances for the speech from CHILDES were automatically estimated by the CLAN system (MacWhinney, 2000), which uses an identical method.

Results

We first describe the audio recordings that make up our picture book reading corpus, including the individuals that appear in the recordings and the number and length of the recordings. We then describe the content of the audio recordings, including the proportions of total words and complex sentences contained in the book text that were read aloud by caregivers. Finally, we compare the language contained in the audio recordings of picture book reading to other conversational contexts, drawn from existing recordings in the CHILDES corpus (MacWhinney, 2000).

Description of the audio recordings

Individuals in the Recordings. In nine of the 12 families, a female caregiver (the mother) read the picture books in all audio recordings. In two families both a male and female caregiver (mother and father) each contributed audio recordings of reading sessions, and in one family a male caregiver (the father) read the books in all audio recordings. Out of the 12 families 10 only had one child participating in the recording sessions and two families included an additional child – an older brother (4 and 5 years of age). The four-year-old brother participated in 2 out of the 6 total recordings

and the 5-year-old participated in 9 out of 11 total recordings made by families. Though sibling speech was transcribed, it is not included in the current analyses.

Book Reading Recordings. The corpus consists of 60 individual book reading sessions summarized in Table 4 (mean per family: 5; range: 2-11). Families spent on average about 10 minutes reading one book (range 1-24 minutes). These results are comparable to and build upon the earlier reports that families spend between 3 and 15 minutes per book (Anderson-Yockel & Haynes, 1994; Cronan et al., 1996; Haynes & Saunders, 1998; Lyytenin et al., 1998).

Table 4. ***Book Reading Session Descriptive Statistics***

Families	Books	Cumulative duration (hour)	Reading time per book (min) (SD)
Family 1	5	0.88	10.60(4.98)
Family 2	7	1.31	11.29(2.63)
Family 3	11	1.21	6.64(4.03)
Family 4	7	1.18	10.14(4.41)
Family 5	3	0.52	10.33(5.69)
Family 6	3	0.22	4.33(2.31)
Family 7	4	0.40	6.00(4.69)
Family 8	3	0.47	9.33(3.21)
Family 9	8	1.97	14.75(6.59)
Family 10	3	0.62	12.67(5.51)
Family 11	2	0.13	4.00(2.83)
Family 12	4	0.67	10.00(3.46)
Total:	60	9.58	9.17(3.30)

We observe considerable variability in book reading duration both within and between families. Overall, families spent more time reading the longer books which contained more text. Figure 1 illustrates reading times of each book by each family,

and clearly shows that overall families spent less time reading the book with the least amount of text (*That is Not a Good Idea*).

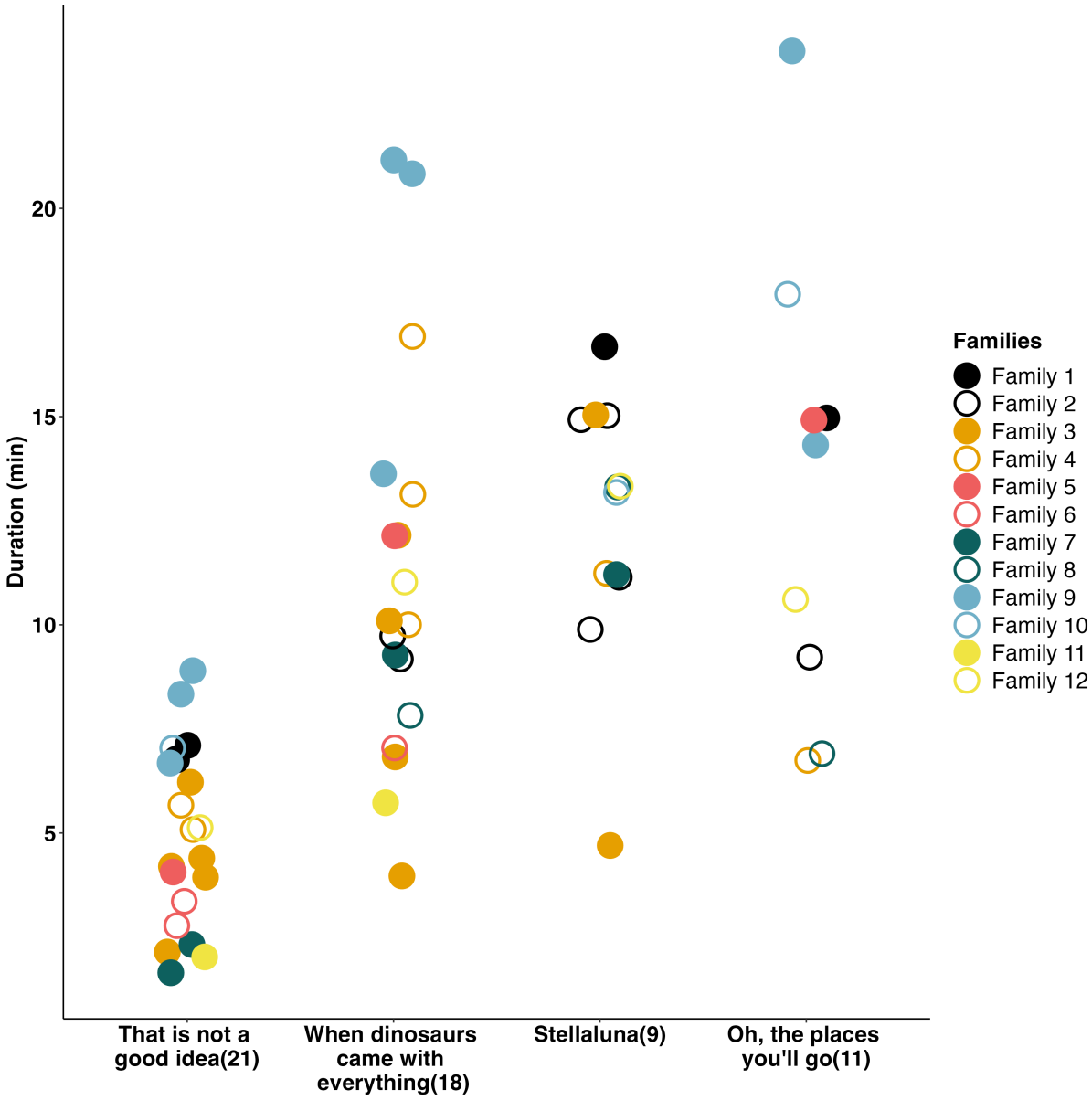


Figure 1. ***Reading duration by book and family; 1 point = one book, so each family may contribute multiple points to a single column; Recording counts by book are included in parenthesis***

Figure 1 also illustrates considerable variability across families, with some families consistently spending more or less time on a single book than others. For example, family 9 (blue filled circles) generally spent more time than average on each book and family 7 (green filled circles) generally spent less time. There was enormous variability across individual book reading episodes, and both features of the books and family individual differences contributed to overall reading times.

Analysis of the audio recordings

The first question we aimed to answer was whether families consistently read the book text aloud during shared book reading. If families do indeed read the book text aloud, differences in lexical diversity and syntactic complexity between the language in book text and typical child directed speech may be a plausible mechanism by which picture book reading may contribute to language outcomes.

Word Proportions. We first computed the overall proportion of the book text that was read aloud during the reading of each book. Caregivers occasionally re-read portions of text and these re-reads were counted only once. The proportions thus refer to the proportion of text read aloud, verbatim, at least once. Figure 2 indicates that caregivers overwhelmingly read all the text contained in the picture books. In only 7 reading instances across all 60 episodes did caregivers skip words. In four of these book reading episodes, parents summarized the text of the book and gave the child a warning before reading the book that they intend to summarize not to read word-for-word from the books. In the remaining three book reading episodes (all instances of "Stellaluna") parents summarized the plot from one to two pages for each of the reading episode without indicating to the child that they were summarizing. Only 3 families ever engaged in the summarizing behaviour while the remaining 9 families read all the words in every book they read (See Online Supplemental Materials Exhibit A for the visualization of word proportions by families).

Sentence Structure. In addition to the proportion of total words, we also measured how often the target complex syntactic constructions were read verbatim and unchanged by caregivers. Here we took a very conservative approach and noted any change that was made to the complex sentence, including the addition of extra words not in the text.

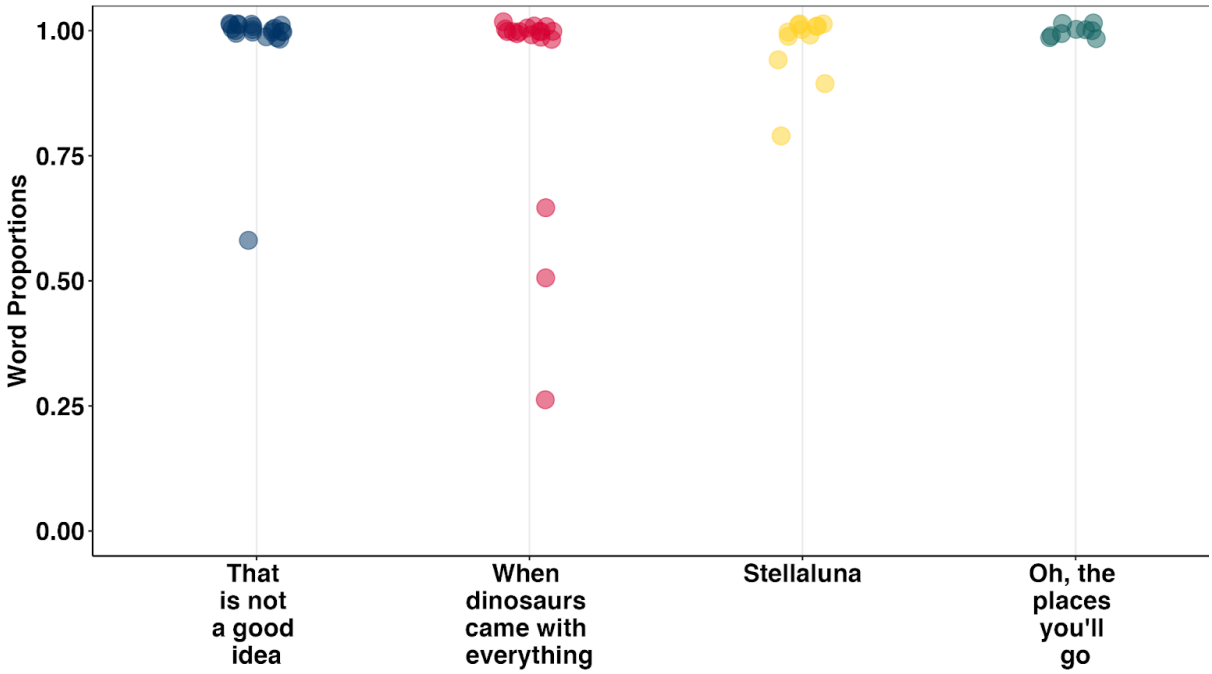


Figure 2. ***Proportion of words in the book read aloud verbatim; 1 point = 1 book, so each family may contribute multiple points to a single column***

The complex syntactic constructions in the books were indeed consistently produced by caregivers (Table 5). Out of 207 target constructions approximately 85% (175) were read from the book without any modification. The type of modification in the remaining 32 complex syntactic constructions are summarized in Table 5 (see Online Supplemental Materials Exhibit B or a complete list and the counts of syntactic constructions by modification types). Most modifications were additions before or after the target construction (25 out of 32 total), so the caregiver read the entire construction aloud but added a word or words of their own, sometimes a relative pronoun and sometimes a re-statement of, or commentary on, the complex construction. Only 5 instances were modifications of the syntactic constructions proper. Three of those five modifications were the addition of extra words in the construction and the remaining two were instances in which the caregiver did not read the construction. That means that the complex construction was produced intact 99% (205/207) of the time, and intact and unmodified in any way 98% (202/207) of the time. In our sample, the rare and complex sentences in picture books do indeed become a part of the linguistic input produced during shared book reading. Picture books may be an important source of complex syntax for children because adult caregivers seem to consistently read the complex language in the book text aloud.

Table 5. ***Summary of the modification types. Added words are indicated with an underline, omitted words are indicated with a strikethrough.***

Modification type	Example	N=32
Addition or omission before construction	And you may ~~not~~ find any you'll want to go down$_{ORC}$	4
Addition after construction	You'll be left in a Lurch$_{Passive}$ *Parent:* Oh.. his poor balloon got caught up in a tree	21
Repetition	*Parent:* You can steer yourself any direction you choose$_{ORC}$ You can steer yourself any direction you choose$_{ORC}$	2
Addition within construction	Stellaluna was terribly hungry – but not for the crawly things that Mama Bird brought$_{ORC}$	3
Omission	~~The places you'll go~~ $_{oblique}$~~;~~	2

Differences between book reading and other conversational contexts

To further understand the language generated during picture book reading, and how it may vary from other sources of child-directed speech, we compared aspects of the language produced during picture book reading to the language produced in other contexts. The present analyses aim to explore whether conversation generated during book reading is indeed characterized by conversation turns, large amounts of speech, and lexically diverse speech, relative to other contexts. We also investigate variability in turn taking and features of produced speech across different books.

We chose the transcribed Bates (1988) corpus available through CHILDES as the source of other conversation contexts to which we compared our picture book reading. First, we needed a comparable number of caregivers and typically developing children that matched the participants in our sample on age and gender. Second, we needed interaction clips comparable in length to our own book reading recordings that reflect different conversation contexts. The Bates corpus fit our criteria and allowed us to compare our audio recordings to those made in different contexts: snack time, free play, and another picture book reading event (*Miffy in the Snow*; 288 words, 0 rare/complex sentence types per our coding scheme). All these contexts were

recorded in the laboratory. Children were approximately age and gender matched to those in our sample (all 28 months; 7 girls, 5 boys), and as in our sample, mostly from a middle-class background. Each child-parent dyad participated in all three of the events for 10 minutes each.

Turn-Taking. We define a turn as a back-and-forth speech-exchange between a child and an adult within 5 seconds, following the traditional methodological convention (Hart & Risley, 1989). We wrote a turn-taking counting algorithm in Python (included in the supplemental materials) that used the speaker tags and utterance timestamps to compute turn taking counts. Given the noisiness of naturalistic transcripts we were unsure whether our simple code would yield accurate turn counts so additionally, three raters manually counted turns for all 60 book reading episodes. Raters discussed their individual counts until a common agreement was reached. These counts overwhelmingly agreed with each other (0.94 interclass correlation coefficient), and we report the manual counts here. The Bates corpus transcript does not contain utterance timestamps, so we could not use own Python code to compute turn counts. However, the CLAN program available for CHILDES transcripts (CLAN, MacWhinney, 2000) can compute turn counts. To ensure that this CLAN algorithm uses similar criteria as own method, two independent raters sampled 10 random clips from Bates and counted turns manually. These counts were similar (0.91 interclass correlation coefficient) to the counts provided by the CLAN algorithm, so we report the algorithm counts here.

Turns per Minute. To better compare across speaking and reading episodes that varied in duration, raw count of turns for each episode were divided by the time of the episode to compute the number of turns per minute (Figure 3). We see considerable variability within each context, but two trends emerge. First, we do not find that book reading contexts contain more conversational turns than other contexts. The snack and free play contexts both elicited high counts of conversation turn and both the short book from CHILDES (*Miffy in the Snow*) and our corpus (*That is Not a Good Idea*) elicited more turns than the longer books. We do not believe that the overall higher rate of conversation turns in the Bates corpus can be attributed to methodological differences in how turn counts were computed, because we manually computed turn counts from the written transcript of each corpus using similar criteria. However, there is a potential confound such that the Bates corpus was recorded in a laboratory setting so both children and caregivers might have behaved differently than they would at home. That said, even within the Bates corpus, the book reading activity did not lead to more conversational turns than other contexts. At the very least, we can conclude that if there is a true effect that book reading promotes more turn taking than other contexts, this effect is small enough such that is it swamped by differences in recording context (home or lab). Our data is also consistent with the interpretation

that book reading contexts do *not* systematically lead to more turn-taking (in dyads with children of about 2.5 years of age) than other conversational contexts.

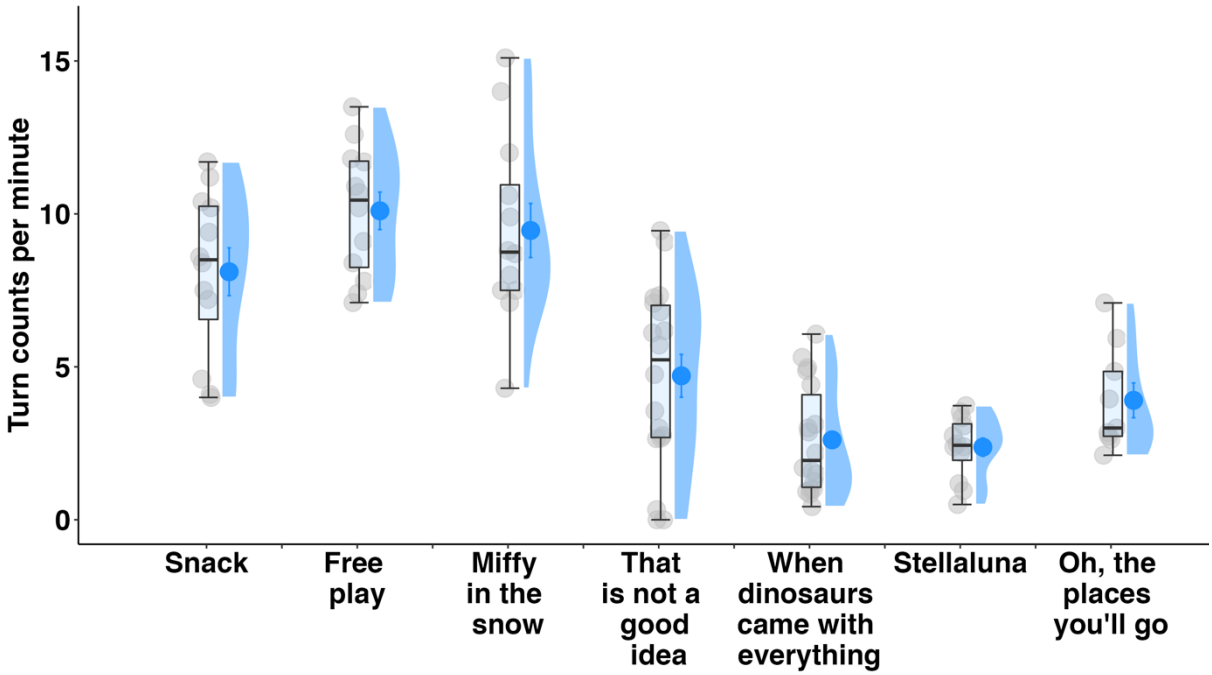


Figure 3. ***Turn taking per minute by book and family; 1 point = one reading session***

Second, different books generated different numbers of conversational turns. The short and syntactically simple books *Miffy in the Snow* (mean: 10; range 4-15) and *That is Not a Good Idea* (mean: 5; range 0-9.2) elicited the highest count of turns per minute. This is not surprising given that the text of these books is very simple with many pages consisting of only a few words, and much of the story is conveyed through the pictures, which depict events not otherwise described in the text. The three other books yielded similar rates of turn taking: *Oh, the Places You'll Go* (mean 3; range: 2-7), *When Dinosaurs Came with Everything* (mean: 2.5; range 1-5) and *Stellaluna* (mean: 2.5; range 1.5-3). These books all contain more words of text and more detailed stories or narratives. In fact, the books that numerically generated the least conversational turns (*When Dinosaurs Came with Everything* and *Stellaluna*) tell complete stories from beginning to end that are surprising and complex: A boy accompanies his mother on a number of errands and receives a free dinosaur from each establishment they visit (*When Dinosaurs Came with Everything)*, and a story about a bat who is temporarily separated from her mother and lives with a family of birds before finding her mother again (*Stellaluna)*. One possible explanation of the observed data is that different

books afford different reading styles. Some books, given their text or pictures, afford lots of back-and-forth conversation between children and their caregivers. Other books, especially those with complex stories conveyed through the text alone, may promote more silent listening of the story.

Age effect. To better understand how a child's own age might affect turn counts, we examined the turns counts per minute across four books of interest as a function of child age (Figure 4). The number of turns per minute for all the books *decreased* with age (r=-48, p<.001). The correlation with MBCDI score also yielded a negative correlation (r=-.38, p<.01). However, when the child who had the MBCDI score in the lowest 5% bracket was removed from the analyses the correlation between turns per minute and MBCDI score was not significant (r=-.03, p>1). Nonetheless, we do see some evidence that younger children, possibly due to their weaker language skills, or perhaps for another reason, engage in more conversational turn taking than older children. We anecdotally notice when listening to the audio that older children tended to genuinely enjoy passive listening to the story, particularly the longer and more complex stories. Perhaps the children whose age or language skills allow them to understand and appreciate the story prefer to silently listen, while children who cannot yet understand or appreciate a longer narrative (and their caregivers) use book reading as a more interactive, conversation-generating activity.

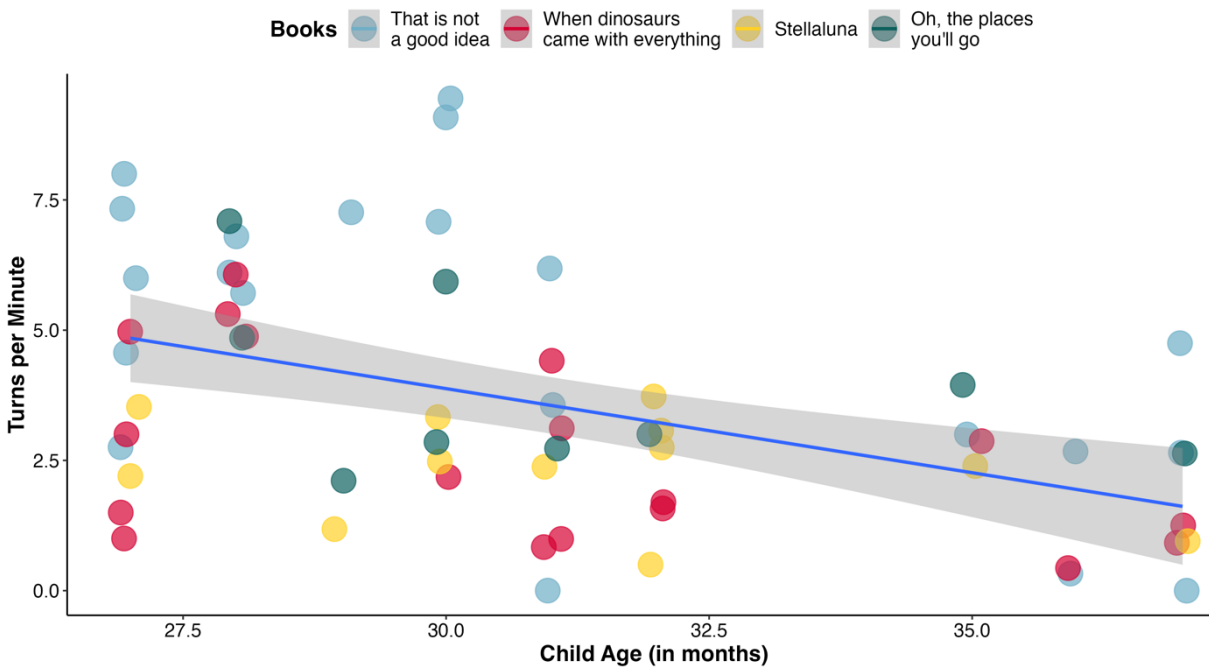


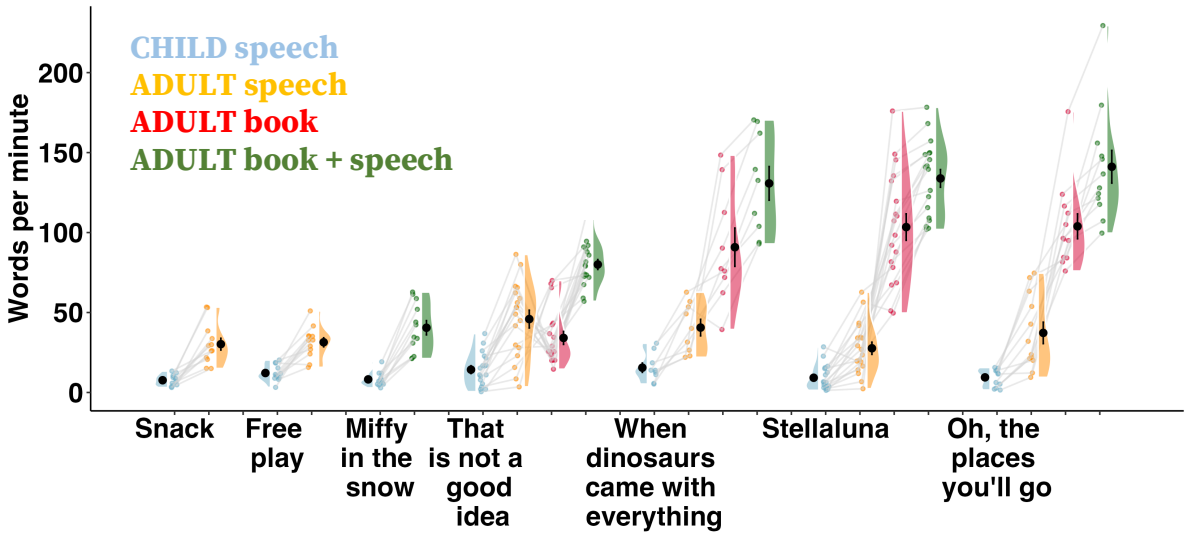
Figure 4. ***Turn taking per minute by child's age; 1 point = one book***

The number of turns highlight only one dimension of caregiver-child speech. The speech measures we report next: the total words per minute, the number of unique words, and mean length of utterance for children and their caregivers, across the seven contexts, provide a clearer picture of differences across conversational contexts. These counts also appear less sensitive to the potential confound (laboratory setting versus at-home recording) that may be present in the turn-taking counts.

Characteristics of caregiver and child speech

To understand how different conversational contexts affect speech characteristics of children and caregivers, we investigated various features of the speech produced in our picture book reading contexts and the Bates recordings. We investigated (1) the total number of words, (2) the number of unique words and (3) the mean length of utterances produced in different contexts. Importantly, for the picture book reading contexts, we look at the book text and extra-textual talk separately to understand the contribution of both to the overall language produced.

Figure 5 illustrates all three measures per individual reading session. In these figures, the blue points refer to child counts, the yellow refers to adult counts in extra-textual talk only, the red points refer to adult counts in read-aloud book text only, and the green points refer to counts in all adult speech (merging extra-textual talk and read-aloud book text). In non-book reading contexts, there are only blue and yellow points because there is no book text to read aloud. The *Miffy in the Snow* context is not broken down into book text and extra-textual talk because this distinction was not annotated in the written transcripts as we did in our own transcripts. Table 6 contains means and standard errors.



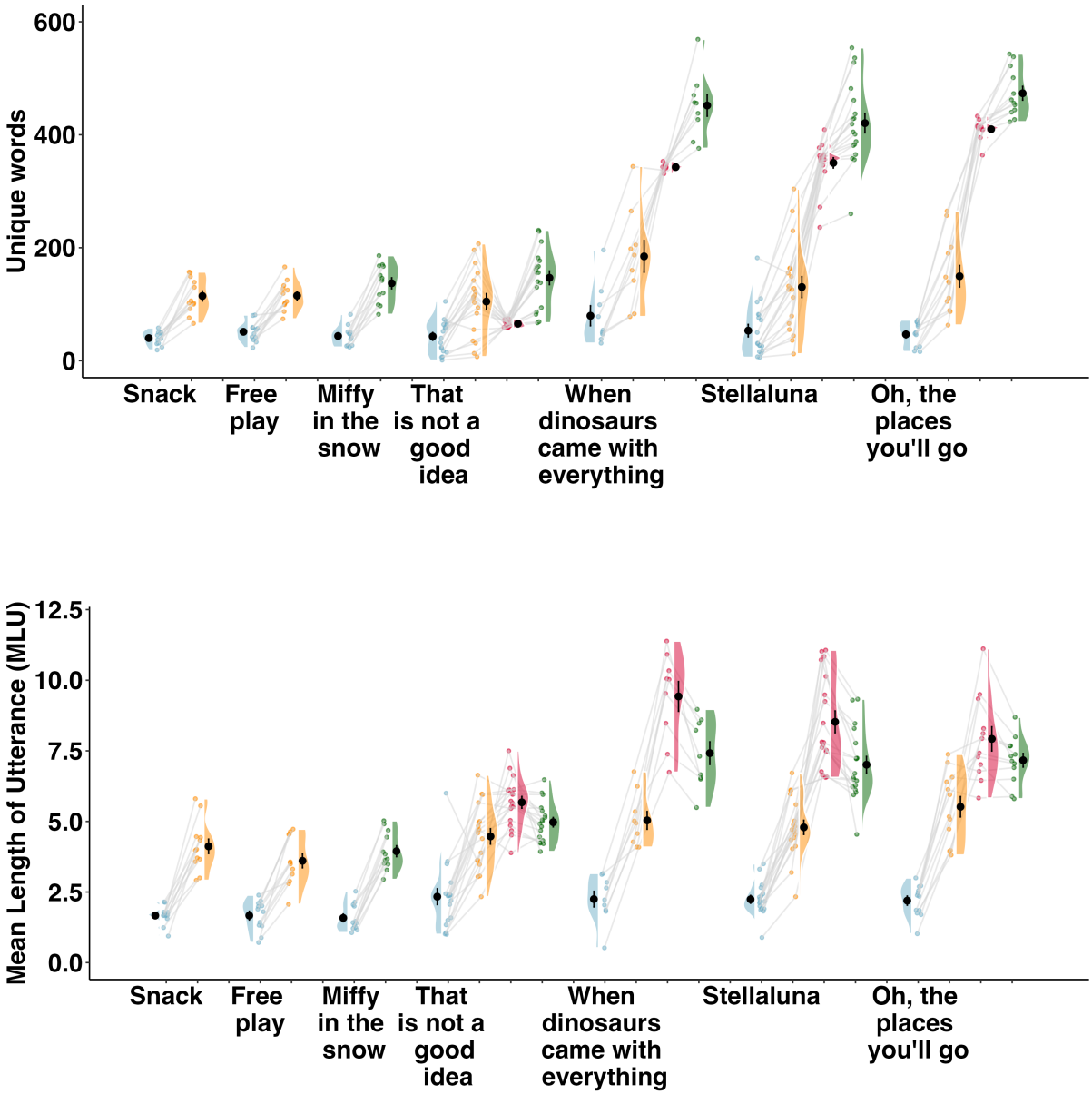


Figure 5. ***Words per minute, unique words and mean length of utterances (MLU) by different context; points connected with lines = one reading or speaking episode***

Table 6. Speech characteristic means with standard error (se) across different contexts

Measure	Speaker	Speech Type	Context: Mean (se)						
			CHILDES			Novel Corpus			
			Snack	Play	Miffy	Idea	Dino	Stellaluna	Places
Words per minute	Child	Speech	8 (.98)	12 (1.46)	8 (1.28)	18 (3.89)	9 (1.83)	9 (1.57)	16 (2.94)
	Adult	Extra-textual talk	30 (3.69)	31 (2.83)	na	46 (5.57)	28 (3.83)	37 (6.72)	41 (5.19)
		Book text read aloud	na	na	na	34 (4.08)	103 (8.29)	104 (7.79)	91 (11.99)
		Extra-textual talk + book text	na	na	41 (4.47)	80 (3.11)	128 (8.02)	141 (10.24)	131 (10.55)
Total words	Child	Speech	77 (9.84)	122 (14.59)	82 (12.84)	97 (17.92)	128 (35.55)	114 (20.25)	230 (73.15)
	Adult	Extra-textual talk	302 (36.91)	314 (28.33)	na	280 (47.82)	348 (70.86)	463 (95.00)	566 (116.71)
		Book text read aloud	na	na	na	145 (4.15)	1019 (37.40)	1214 (32.11)	1043 (23.42)
		Extra-textual talk + book text	na	na	405 (44.74)	425 (49.33)	1360 (117.22)	1677 (104.16)	1600 (109.87)
Unique words	Child	Speech	40 (3.47)	51 (5.08)	44 (5.00)	43 (6.82)	53 (10.94)	47 (6.13)	80 (17.68)
	Adult	Extra-textual talk	115 (8.92)	115 (7.38)	na	105 (13.97)	130 (18.49)	150 (19.05)	185 (28.03)
		Book text read aloud	na	na	na	65 (1.26)	350 (9.14)	410 (4.96)	343 (2.10)
		Extra-textual talk + book text	na	na	137 (9.70)	147 (12.09)	402 (23.50)	474 (12.21)	452 (19.04)
MLU	Child	Speech	1.67 (.10)	1.67 (.15)	1.58 (.14)	2.34 (.28)	2.24 (.14)	2.19 (.16)	2.25 (.28)
	Adult	Extra-textual talk	4.12 (.25)	3.61 (.25)	na	4.47 (.27)	4.79 (.25)	5.52 (.36)	5.04 (.32)
		Book text read aloud	na	na	na	5.68 (.21)	8.53 (.39)	7.92 (.43)	9.43 (.53)
		Extra-textual talk + book text	na	na	3.95 (.19)	4.81 (.23)	7.01 (.29)	7.17 (.24)	7.42 (.40)

Words per minute. Caregivers produced more words per minute during book reading than other activities. In three out of the four books we provided families the extra-textual talk consisted of more words per minute than other activities (28, 37, 41 and 46 words per minute vs. 30 and 31 for snack and play) but these rates of speech

grow substantially with the presence of book text spoken aloud (80-141 words per minute). Caregivers in our sample overwhelmingly read all the book text, which contributed a substantial number of words to the interaction. The smallest contribution of text read aloud was found for the shortest book in our sample (*That is Not a Good Idea)* which incidentally also generated the most conversational turns. These findings are consistent with variability across books. Books that afford greater back-and-forth conversation generate more words of extra-textual talk, but longer books that afford more passive listening generate more caregiver words overall.

We observe small differences in the amount of child speech across books and non-book contexts. Some books, including *That is Not a Good Idea* generated more child words per minute than snack time or free play, while other books generated word counts approximately equal to those produced during non-reading activities.

Unique words. The fact that caregivers and children often produce more words per minute during shared book reading does not mean that these words are qualitatively different from the words produced in other contexts. To understand possible differences in the speech that is produced, we examine the number of unique words and the mean length of utterances elicited during book reading and other contexts. That is, we counted the number of unique words produced in each context. However, a methodological challenge arises such that while number of unique word types increases as the total number of word tokens increases, the rate of increase necessarily slows as the sample size gets larger given constraints of natural language (Heaps, 1978; Herdan, 1960; see also Malvern et al., 2004; McKee et al., 2000; Montag et al., 2018; Richards, 1987). Put simply, ratios of unique words to other words, such as type-token ratios are so confounded by sample size that they make poor estimates of unique word counts or lexical diversity measures. For this reason, we report only counts of unique words to avoid a measure of lexical diversity that is deceptively contaminated by total word counts. While unique word counts are not a measure of lexical diversity, they do provide some information about the range of vocabulary items that are present in a conversational context and how contexts might vary, even if they also vary in the total number of words produced. Figure 5 illustrates that caregivers produced more unique words during book reading than during other activities. Once again, this pattern was particularly true of the three longer, more complex books, where, again, the effect was largely driven by the presence of book text spoken aloud.

To illustrate the lexical diversity of speech samples in a way that is independent of total word counts we plot the number of unique words in caregiver speech that included both book text and extra-textual talk in similarly sized samples in Figure 6. As a workaround for the confound of the Bates corpus (all speech collected in a lab setting), we included additional 40 age-matched conversations from CHILDES corpus: Peter (Bloom, et al., 1974; Bloom et al., 1975), Adam and Sarah (Brown, 1973), and

Nina (Suppes, 1974) that were recorded at home (grey dots labelled CHILDES). These additional recordings may encompass a range of contexts and we neither selected nor excluded recordings on the basis of the conversational context. Figure 6 shows the number of unique words in samples that increase in increments of 10 words (i.e., first 10 words, then first 20 words, and so on), averaged across each transcript of the same context. The error bars refer to one standard deviation in the average number of unique words. The error bars become smaller and disappear and values appear noisier as the samples get longer because transcripts varied in length, so fewer transcripts are included in the means as the total word counts increases. The vertical spread of y-values at a single x-value can be interpreted as a difference in lexical diversity. For example, at 500 total words, snack and free play contexts (black and orange dots respectively) contain approximately115 unique words, the additional at-home CHILDES samples contain about 150 unique words while *Stellaluna* (yellow dots) contains nearly 100 more unique words (218 unique words).

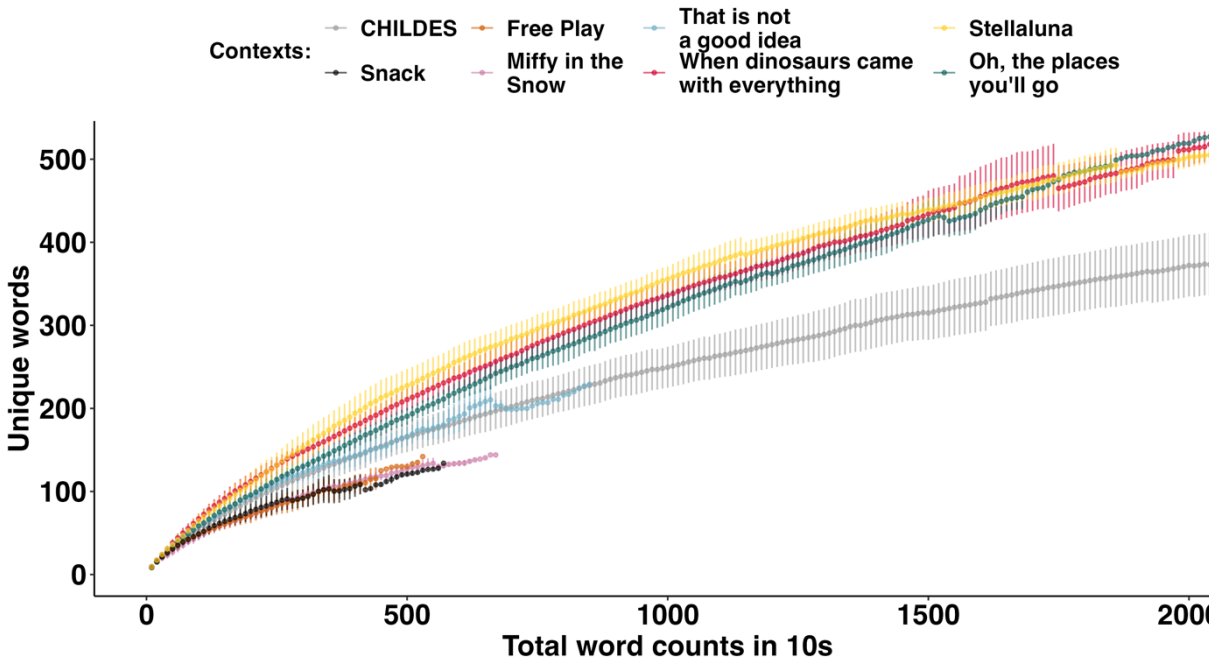


Figure 6. ***Unique word means over the total words in 10-word increments by different contexts. Error bars = 1 standard deviation***

We observe far more unique words in similarly sized speech samples during at-home shared reading events than in other contexts, including other at-home contexts. It is unclear why we count fewer unique words in the Bates corpus recordings than in other additional at-home CHILDES recordings. This difference may be due to the differences in population, recording, or experimental methodology. We also observe

differences across the four books in our sample. The book reading sessions with longer books elicited more unique words, likely reflecting the large amount of lexically diverse book text that was read aloud. Further, the book that generated the most extra-textual words per minute (*That is not a good idea*) overall showed the least lexically diverse speech. Again, we see a trade-off, such that books that generated more speech, including more child speech per minute generated less lexically diverse caregiver speech.

Mean Length of Utterance. Caregivers produced longer utterances during book reading than other activities. Again, this pattern was particularly true of the longer, more complex books, and this pattern was largely driven by the presence of book text that is spoken aloud. The most syntactically complex books generated the longest mean length of utterances, which is consistent with the finding that caregivers indeed read book text aloud. Children also consistently produced longer utterances (on average about an extra half a word per utterance) during book reading at home than in other contexts, though we see only small differences across different books.

Discussion

We built a corpus of caregiver-child interactions during shared book reading recorded in homes to better understand the language that is produced during shared book reading. We found that caregivers overwhelmingly read the book text, including rare and complex sentence structures. We also found that books varied in the profiles of language they generated, with some books promoting more conversational turns and extra-textual language, while others promoted more overall words, unique words, and longer utterances. Further, relative to other conversational contexts, book reading generally generated overall more words, more lexically diverse talk, and longer utterances, but these tendencies were driven by the presence of book text read aloud, so they depended on characteristics of the book being read. Rather than a single profile of speech generated during book reading, different books may promote different profiles of caregiver-child interaction.

The goal of better understanding the language generated during shared book reading was to aid in establishing the plausibility (or implausibility) of causal pathways by which shared book reading might positively contribute to language outcomes. Hypotheses surrounding the reasons book reading may be associated with positive language outcomes often focus on features of the language or conversation generated during book reading, so evaluating these hypotheses requires a better understanding of the language generated during shared book reading. Our first key finding was that caregivers indeed consistently read the text of the picture books, so findings that picture book text is more lexically diverse and syntactically complex are indeed germane to the language environment generated during shared book reading. We replicate

existing findings that the language produced during picture book reading is more lexically diverse than language produced in other contexts (e.g., Crain-Thoreson, et al., 2001; Demir-Lira et al., 2019; Hoff-Ginsberg, 1991; Mol & Newman, 2014; Salo, et al., 2016; Sosa, 2016; Weizman & Snow, 2001). Our work further clarifies these findings by showing explicitly that the increases in MLUs, speech rate (word count per minute), and unique words during shared book reading relative to other contexts are driven by the book text. The difference between speech in non-book contexts and speech in book reading contexts is largely driven by the presence of book text read aloud. Additionally, while child speech during book reading sessions did not elicit more conversational turns than during other contexts, children produced more words, more unique words and higher MLUs during longer book reading sessions than in any of the other contexts. These results suggest that child speech produced during book reading sessions perhaps is not part of back-and-forth conversation per se but rather in response to the book text read aloud that children heard.

With respect to the extra-textual talk, including turn-taking generated during shared book reading, our analyses suggest that the nature of this extra-textual talk depends a great deal on features of the book being read. Our book with the least amount of text, with pictures that tell aspects of the story that are not present in the text, generated the densest turn taking, while the books with more text and complex narratives generated the least turn-taking. This result replicates earlier findings showing that stories with less text facilitate more extra-textual talk per minute than stories with more book text (Chaparro-Moreno et al., 2017; Greenhoot, et al., 2014; Muhinyi & Hesketh, 2017; Petrie et al., 2021). While we do not want to overgeneralize our findings on the basis of only four different books, it is certainly the case that there is enormous variability in the text and pictures of picture books. Some of this variability likely reflects creative choices on the part of the authors and illustrators to vary how caregivers and children interact with the book, so it is not surprising that we observe variability across books in the profiles of speech and conversation that they generate.

More surprising, we find that shared book reading did not necessarily generate more conversational turns than other conversational contexts, like snack time or playtime. The Bates corpus, to which we compare our corpus, was collected in the lab while our shared book reading recordings were recorded at home, and this difference may have affected caregiver behaviour. One speculative possibility is that adult caregivers are not comfortable with silence in such formal unfamiliar environments as laboratory settings. Consequently, they produce large amounts of speech that is quite simple: more back-and-forth, but shorter, simpler utterances and more repetition. However, we do find that our shared book reading interactions generated fewer conversational turns than the activities in the Bates corpus, and even within the Bates corpus the picture book reading did not generate more conversational turns than eating a snack or playtime. That said, our book that generated the most conversational turns indeed

generated more child words per minute than any other reading or non-reading context. More work documenting turn taking across different, ideally naturalistic contexts, is needed to draw stronger claims, but we find mixed evidence for the idea that shared book reading promotes turn-taking and child speech because there was substantial variation across books, families, and non-book contexts.

Given the emphasis on extra-textual talk in the picture book reading literature, as in dialogic reading and other approaches, it may be unexpected that we observe such low rates of extra-textual talk. There are many reasons for this potential discrepancy. One potential explanation is that there is in fact no discrepancy at all—our simplest book (*This is not a good idea*) generated similar rates of extra textual talk as did other episodes reported in the literature. In our simplest book, 58% of caregiver words were extra-textual. In a sample of 2–27-month-old children and their caregivers reading similarly simple books, Cline and Edwards (2017) report that 67% of word were extra-textual and in a sample of 18–30-month-old children and caregivers spontaneously reading books at home, Demir-Lira et al. (2019) find that 76% of utterances were extra-textual. If utterances in which caregivers read the book text are longer than extra-textual utterances (as they were in our analysis), these figures are broadly consistent with what we find. Our findings are not in contrast with existing results, but rather compliment and extend the literature to emphasize book effects, that the type of book that families are reading has enormous implications for the speech that caregivers and children produce.

Methodological differences may also underlie other observed discrepancies between our findings and other findings in the literature. The children in our sample were between about a year younger (Gilkerson et al. 2017; Lonigan & Whitehurst, 1998; Muhinyi et al., 2019; Muhinyi & Hesketh, 2017) or up to 3 years younger (Mol & Newman, 2014; Grolig et al., 2020; Payne et al., 1994) than many other studies that record caregiver-child interactions during book reading. Given clear age-related differences in caregiver speech during book reading (e.g., Patel et al., 2024; Senechal et al, 1995), the age of the children in our sample may contribute to the lower rates of caregiver utterances for some of our books. Another important methodological difference is that families used the audio recorder in their homes, with no experimenter present. Families were in a familiar location, were not being observed or videotaped, and were asked to keep the audio recorder out of sight, so it may have been easier to "forget" that they were being recorded and act more naturally, or at least differently, had the recording been more obvious. Finally, our sample is small and somewhat homogenous, so it is certainly possible that our sample demographics contributed to our observed results.

We interpret our results as suggesting that there may indeed be a plausible, causal relationship between picture book reading and language outcomes because we

observed differences between various aspects of conversation and speech between picture book reading and other activities. Hypothesis about the utility of picture book reading generally focus on aspects of the language generated during book reading and how it may be different from other conversational contexts. While our analyses do not themselves advance claims of causality, our analyses suggest that these hypotheses surrounding the language generated during book reading are plausible, sensible candidate for mechanistic pathways by which picture books come to be associated with language outcomes. However, the pathway may be that reading provides a varied range of diverse experiences rather than any one feature.

The two non-mutually exclusive explanations for the positive effects of picture book reading, caregiver-child conversation and vocabulary and sentence structure of the book text, may both be correct, but in different contexts for different books. Some books may promote turn-taking and child speech, others varied vocabulary or rare syntax, still others facts about the world, and so on. Variability of experience with very different profiles of reading across books may be an important contribution of book reading to children's language environments. Variability of experience would also help explain why interventions that aim to alter caregiver reading behaviour may not be associated with better language gains than an active control group (e.g., Noble et al., 2020). Perhaps, it is not a specific style of reading or type of input that contributes to language outcomes but rather varied experience with a range of reading styles and language profiles.

We speculate that further support for the idea that a varied range of experiences underlies observed language benefits of shared book reading is found in our negative correlation between age and turn taking. If turn-taking or child productive language were a central goal of book reading, turn-taking should increase as a child's own language skills support such conversation. Perhaps children (and their caregivers) who had the language skills to understand the story preferred to listen to the story and engage in less conversation. If this is a common behaviour across families, it may be normatively true that shared book reading is not always accompanied by a great deal of extra-textual conversation, which is relevant when evaluating correlational studies that associate shared book reading with positive language outcomes. Our result is consistent with other reports of a negative effect of age on caregiver speech (Muhinyi et al., 2020), and may suggest a more complicated relationship between child age, extra-textual speech and other family factors that may contribute to caregiver extra-textual talk.

More generally, this work points to the importance of the developing child in creating their own language environment. Our age-dependent effects on conversation are exploratory, but we think the ways that picture book reading changes as a function of child age or language skills is a potentially interesting finding worth of future work

and relates to existing work describing developmental cascades. The negative effect of age on caregiver-child turn-taking suggests that child characteristics may shape the nature of the book reading episode. This finding is consistent with work that finds that either implicitly or explicitly caregivers can accommodate their child's linguistic knowledge when producing utterances (Huttenlocher et al., 2010; Leung et al, 2021) or more broadly, that a child's own linguistic, motor, or other abilities can have effects on the aspects of their environment (e.g., Bradshaw et al., 2022; Karasik,Tamis-LeMonda & Adolph, 2014; Kretch et al, 2014; Oakes, 2023; Thelen & Smith, 1994). The role of the child in shaping their own language environment provides an additional complication for systematic investigations of shared book reading as an intervention, because the same book or book reading intervention may produce different language experiences for different children.

We hope that future work can build about the present work. We collected recordings from only a narrow age range of children, so future work is necessary to better understand how child age and other characteristics might interact with book characteristics over a larger age range. Further, studies with larger and more diverse samples that include child language and literacy development measures are necessary to more directly link book reading with language outcomes and generalize these findings across larger populations of children. Our immediate goal of transcribing and annotating the recordings to create a sharable corpus necessitated this small sample, but expanding the sample would be an obvious next step. Future work could also collect book reading and other non-book reading speech samples from the same caregiver-child dyads to address the limitations associated with comparing book reading and other caregiver-child episodes across different children and families.

A remaining empirical question is to what degree the variability across different book profiles we observed may or may not extend to books outside our sample, including books that are familiar to families. In the present work, we limited our analyses to four books that were novel to families. These books may not be a representative sample of picture books for any number of reasons. For example, reading styles may vary considerably when reading books that are familiar to children and caregivers. Caregivers might summarize the text more frequently because they are familiar with the plots, or they may summarize less frequently because they are more familiar with the text. Likewise, familiarity with the plot, text or pictures may affect (in any direction) the amount of extra-textual conversation with which a family engages (Fletcher & Finch, 2015; Read et al., 2023). We hope to answer these questions in ongoing work with the book reading events in our corpus in which caregivers and children read books they already owned at home to gain a more complete picture of naturalistic shared book reading.

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Data, code and materials availability statement

The data and analytical scripts used in the study are available at **https://osf.io/b3egw** Audio files and transcripts in ELAN and CHAT formats are available at https://childes.talkbank.org/access/Eng-NA/StoopsMontag.html

Ethics statement

The research reported was conducted in compliance with APA Ethical Standards regarding the treatment of human participants and the University of Illinois IRB protocols.

Authorship and Contributorship Statement

JLM conceived and designed the study and co-wrote and revised the manuscript with

AS. AS contributed to the design of the study, collected and analyzed the data and wrote the manuscript. MW and IHTJ analyzed portions of the data. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declaration of conflict of interests

We report having no competing interests.

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