Comparing Language Input in Homes of Blind and Sighted Children: Insights from Daylong

Recordings

Erin Campbell[1,2], Lillianna Righter[1,3], Eugenia Lukin[1,3], & Elika Bergelson[1,3]

[1] Department of Psychology & Neuroscience, Duke University, Durham, NC

[2] Wheelock College of Education & Human Development, Boston University, Boston, MA

[3] Department of Psychology, Harvard University, Boston, MA

Comparing Language Input in Homes of Blind and Sighted Children: Insights from Daylong
Recordings

Abstract

Purpose: This study compared language input to young blind children and their
sighted peers in naturalistic home settings.

Methods: Using LENA audio recordings, naturalistic speech in the home was
captured, transcribed, and analyzed for various dimensions of language input, including
quantitative, interactive, linguistic, and conceptual features.

Results: Our data showed broad similarity across groups in speech quantity and
interaction. Fine-grained analysis revealed that blind children's language environments
contained more lexical diversity, longer utterances, and more temporal displacement.

Conclusions: The findings challenge the notion that blind children's language input
places them at a disadvantage and suggest instead that blind children receive rich and
complex language input that can support their language development.

Introduction

The early language skills of blind children highly variable (E. Campbell, Casillas, &
Bergelson, 2024). Some demonstrate age-appropriate vocabulary from the earliest stages of
language learning (Bigelow, 1987; E. Campbell et al., 2024; Landau & Gleitman, 1985),
while others experience substantial language delays (E. Campbell et al., 2024). By
adulthood, however, blind individuals become fluent language-users, demonstrating faster
lexical processing skills than sighted adults (Loiotile, Lane, Omaki, & Bedny, 2020; Röder,
Demuth, Streb, & Rösler, 2003; Röder, Rösler, & Neville, 2000). The causes of early
variability and the later ability to "catch up" remain poorly understood: what could make
the language learning problem different or initially more difficult for the blind child? Here,

we compare the language environments of blind children to that of their sighted peers. In doing so, we begin to untangle the role that perceptual input plays in shaping children's language environment, and better understand the interlocking factors that may contribute to variability in blind children's early language abilities.

Why would input matter?

Among both typically-developing children and children with developmental differences, language input has been found to predict variability in language outcomes (Anderson, Graham, Prime, Jenkins, & Madigan, 2021, 2021; Gilkerson et al., 2018; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Rowe, 2008, 2012). The many ways to operationalize language input tend to be grouped into **quantity of language input** and **input characteristics** (often referred to as **quality of language input**[1], c.f. MacLeod & Demers, 2023). Quantity can be broadly construed as the number of words or utterances a child is exposed to. At a coarse level, children who are exposed to more speech (or sign, Watkins, Pittman, & Walden, 1998) tend to have better language outcomes (Anderson et al., 2021; Gilkerson et al., 2018; Huttenlocher et al., 1991; Rowe, 2008).

Previous research suggests that the specific characteristics of language input are perhaps even more influential (Hirsh-Pasek et al., 2015; Rowe, 2012), although they are somewhat trickier to quantify into discrete measures. Rowe and Snow (2020) categorized this space into three dimensions: interactive features (e.g., parent responsiveness, speech directed *to* child vs. overheard, conversational turn-taking), linguistic features (e.g., lexical diversity, grammatical complexity), and conceptual features (i.e., the extent to which input focuses on

---

[1] In the present study, we refrain from labeling linguistic characteristics as "quality" measures to avoid perpetuating biased standards favoring certain linguistic norms. The term "quality" has historically stigmatized input from already-marginalized (e.g., people of color, disabled groups) by framing their language as deficient (MacLeod & Demers, 2023).

the *here-and-now*).

Previous studies have indicated that back-and-forth communicative exchanges (also known as conversational turns) between caregivers and children are predictive of better language outcomes across infancy (Donnellan, Bannard, McGillion, Slocombe, & Matthews, 2020; Goldstein & Schwade, 2008) and toddlerhood (Hirsh-Pasek et al., 2015; Romeo et al., 2018). Another way to quantify the extent to which caregivers and infants interact is by looking at how much speech is directed *to* the child (as opposed to, for example, an overheard conversation between adults). The amount of child-directed speech in children's input (at least in Western contexts, Casillas, Brown, & Levinson, 2020) has been linked to children's vocabulary size and lexical processing (Rowe, 2008; Shneidman, Arroyo, Levine, & Goldin-Meadow, 2013; Weisleder & Fernald, 2013).

Under the linguistic umbrella, we can measure the *kinds* of words used (often measured as lexical diversity, type/token ratio), and the ways they are *combined* (syntactic complexity, often measured by mean length of utterance). Both parameters have been found to correlate with children's language growth. Sighted toddlers who are exposed to a greater diversity of words in their language input are reported to have larger vocabulary scores (Anderson et al., 2021; Hsu, Hadley, & Rispoli, 2017; Huttenlocher et al., 2010; Rowe, 2012; Weizman & Snow, 2001). Likewise, the diversity and complexity of syntactic constructions in parental language input has been associated with both children's vocabulary growth and structural diversity in their own productions (De Villiers, 1985; Hadley et al., 2017; Hoff, 2003; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002; Huttenlocher et al., 2010; Naigles & Hoff-Ginsberg, 1998).

The conceptual dimension of language input aims to capture the extent to which the language signal maps onto present objects and ongoing events in children's environments (Rowe & Snow, 2020). As children develop, their ability to represent abstract referents improves (Bergelson & Swingley, 2013; Kramer, Hill, & Cohen, 1975; Luchkina, Xu, Sobel, &

Morgan, 2020). Decontextualized language input– that is, talking about past, future, or hypothetical events, or people and items that are not currently present in the environment– may be one contributing factor (Rowe, 2013); greater amounts of decontextualized language use in input to toddlers has been found to predict aspects of children's own language in kindergarten and beyond (Demir, Rowe, Heller, Goldin-Meadow, & Levine, 2015; Rowe, 2012; Uccelli, Demir-Lira, Rowe, Levine, & Goldin-Meadow, 2019).

From this review, it appears that many factors in the language input alone influence how sighted children learn about the world and language, but they also learn from sensory perception and conceptual and social knowledge. Many cues for word learning are visual: for example, empirical work finds that sighted children can leverage visual information like parental gaze, shared visual attention (Tomasello & Farrar, 1986), pointing (Lucca & Wilbourn, 2018), and the presence of salient objects in the visual field (Yu & Smith, 2012). Because these visual cues are inaccessible to blind children, language input may take on a larger role in the discovery of word meaning (E. E. Campbell & Bergelson, 2022). Syntactic structure in particular may provide cues to word meaning that may be lost, such as the relationship between two entities that aren't within reach (Gleitman, 1990). However, such hypotheses implicitly assume that blind and sighted children receive similar language input.

Why would the input differ between blind and sighted children?

Speakers regularly tailor their speech to communicate efficiently with the listener (Grice, 1975). Across many contexts, research finds that parents are sensitive to their child's developmental level and tune language input accordingly (Snow, 1972; Vygotsky & Cole, 1978). One example is child-directed speech, wherein parents speak to young children with exaggerated prosody and slower speech (Bernstein Ratner, 1984; Fernald, 1989; Moser et al., 2022), which are in some cases helpful to the young language learner (Thiessen, Hill, & Saffran, 2005). For instance, parents tend to repeat words more often when interacting with infants than with older children or adults (Fernald & Morikawa, 1993; Snow, 1972).

Communicative tailoring is also common in language input to children with disabilities, who have been found to receive simplified, more directive language input, and less interactive input compared to typically-developing children (Dirks, Stevens, Kok, Frijns, & Rieffe, 2020; Yoshinaga-Itano, Sedey, Mason, Wiggin, & Chung, 2020).

In addition to tailoring communication to children's developmental level, speakers also adjust their conversation in accordance to their partner's sensory access (Gergle, Kraut, & Fussell, 2004; Grigoroglou, Edu, & Papafragou, 2016). In a noisy environment, speakers often adapt the acoustic-phonetic features of their speech to make it easier for their interlocutor to understand them (Hazan & Baker, 2011), demonstrating sensitivity to even temporary sensory conditions. When describing scenes, speakers aim to provide the information their listeners lack but avoid redundant visual description (Grice, 1975; Ostarek, Paridon, & Montero-Melis, 2019). During in-lab tasks with sighted participants, participants in several studies verbally provided visually-absent cues when an object is occluded to their partner (Hawkins, Gweon, & Goodman, 2021; Jara-Ettinger & Rubio-Fernandez, 2021; Rubio-Fernandez, 2019). These results suggest that adults and even infants (Chiesa, Galati, & Schmidt, 2015; Ganea et al., 2018; Senju et al., 2013) can flexibly adapt communication to the visual and auditory abilities of their partner.

Taking these results into account, we might expect parents to verbally compensate for missing visual input, perhaps providing more description of the child's environment. But prior research doesn't yield a clear answer. Several studies suggest differences in the conceptual features: caregivers of blind children restrict conversation to things that the blind child is currently engaged with, rather than attempt to redirect their attention to other stimuli (Andersen, Dunlea, & Kekelis, 1993; J. Campbell, 2003; Kekelis & Andersen, 1984; though c.f., Moore & McConachie, 1994). Studies of naturalistic input to blind children report that parents use *fewer* declaratives and *more* imperatives than parents of sighted children, suggesting that blind children might be receiving less description than sighted

children (Kekelis & Andersen, 1984; Landau & Gleitman, 1985). Other studies report that parents adapt their interactions to their children's visual abilities, albeit in specific contexts. Tadić, Pring, and Dale (2013) find that in a structured book reading task, parents of blind children provide more descriptive utterances than parents of sighted children. Further, parents of blind children have been found to provide more tactile cues to initiate interactions or establish joint attention (Preisler, 1991; Urwin, 1983, 1984), which may serve the same social role as shared gaze in sighted children. These mixed results suggest that parents of blind children might alter language input in some domains but not others. The apparent conflict in results may be exacerbated by the difficulty of recruiting specialized populations to participate in research: the small (in most cases, single-digit) sample sizes of prior work limits our ability to generalize about any differences in the input to blind vs. sighted infants.

The Present Study

If properties of language input influence the likelihood of language delays among blind infants and toddlers (E. Campbell et al., 2024), capturing this variation may reveal a more nuanced picture of how infants use the input to learn language. In the present study, we examine daylong recordings of the naturalistic language environments of blind and sighted children in order to characterize the input to each group. Using both automated measures and manual transcription of these recordings, we measure input quantity (adult word count) and analyze several characteristics that have been previously suggested to be information-rich learning cues, including interaction (conversational turn count, proportion of child-directed speech), conceptual features (temporal displacement, sensory modality), and linguistic complexity (type/token ratio and mean length of utterance). Though the present study is largely exploratory, based on prior research, we might expect to find less interaction (fewer conversational turns and less child-directed speech), less linguistic complexity (lower type-token ratio and shorter utterances), and conceptual content focused more on the blind child's locus of attention (more here-and-now speech and fewer visual words); we have no a

priori hypotheses regarding language input quantity.

Methods

Participants

15 blind infants and their families participated in this study. To be eligible, participants had to be 6–30 months old, have no additional disabilities (developmental delays; intellectual disabilities, or hearing loss), and be exposed to $\geq 75\%$ English at home. Blind participants were recruited through ophthalmologist referral, preschools, early intervention programs, social media, and word of mouth. Blindness in our sample was caused by a range of conditions, including cataracts (n=3), Leber's Congenital Amaurosis (n=0), Microphthalmia (n=0), Ocular albinism (n=2), Optic Nerve Hypoplasia (n=2), Retinal Detachments (n=1), and Retinopathy of Prematurity (n=1). Etiology was unknown in 2 participants, and 2 participants had multiple contributing conditions. Caregivers were also asked to complete a demographics survey and the MacArthur-Bates Communicative Development Inventory (CDI, Fenson et al., 1994) within one week of the home language recording.

To control for the wide age range of the study, each blind participant was matched to a sighted participant, based on age ($\pm$ 6 weeks), gender, maternal education ($\pm$ one education level), and number of siblings ($\pm$ 1 sibling). Sighted matches were drawn from the multiple existing corpora (Bergelson, 2015; Bergelson, Amatuni, Dailey, Koorathota, & Tor, 2019; Ramírez-Esparza, García-Sierra, & Kuhl, 2014; Caroline Rowland et al., 2018; VanDam et al., 2015; VanDam et al., 2016; Wang, Cooke, Reed, Dilley, & Houston, 2022; Warlaumont, Pretzer, Mendoza, & Walle, 2016), or when there was no recording available that matched a blind participant's demographic characteristics, collected *de novo*. See Table 1 for sample characteristics.

Recording Procedure

For the recording portion of the study, caregivers of participating infants received a LENA wearable audio recorder and vest (Ganek & Eriks-Brophy, 2016; Gilkerson & Richards, 2008). They were instructed to place the recorder in the vest on the day of their scheduled recording and put the vest on their child from the time they woke up until the recorder automatically shut off after 16 hours (setting the vest nearby during baths, naps, and car rides). Actual recording length ranged from 8 hours 17 minutes to 15 hours 59 minutes (Mean: 15 hours 6 minutes).

Processing

The audio recordings were first processed by the LENA proprietary software (Xu, Yapanel, & Gray, 2009), creating algorithmic measures such as conversational turn count and adult word count. Each recording was then run through an in-house automated sampler that selected 15- non-overlapping 5-minute segments, randomly distributed across the duration of the recording. Each segment consists of 2 core minutes of annotated time, with 2 minutes of listenable context preceding the annotation clip and 1 minute of additional context following. Because these segments were sampled randomly, across participants roughly 27% of the random 2-minute coding segments contained no speech at all. For questions of *how much does a phenomenon occur*, random sampling schemes can help avoid overestimating speech in the input, but for questions of input *content*, randomly selected samples may be too sparse (Pisani, Gautheron, & Cristia, 2021).

Therefore, we chose to annotate 5 additional (non-overlapping) segments specifically for their high density of speech. To select these segments of dense talk, we first conducted an automated analysis of the audio file using the voice type classifier for child-centered daylong recordings (Lavechin, Bousbib, Bredin, Dupoux, & Cristia, 2021) which identified segments likely contain human speech. The entire recording was divided into 2-minute chunks, each ranked highest to lowest by the total duration of the speech segments contained within the

chunk. We annotated the highest-ranked 5 segments of each recording. These high volubility segments allow us to more closely compare our findings to studies classifying the input during structured play sessions, which paint a denser and differently-proportioned makeup of the language input (Bergelson et al., 2019). In sum, 30 minutes of randomly sampled input and 10 minutes of high-volubility input (40 minutes total) were annotated per child.

Annotation

Manual annotation of the selected segments was conducted using the ELAN software (Brugman & Russel, 2009). Trained annotators listened through each 2-minute segment plus its surrounding context and coded it using the ACLEW annotation scheme (Soderstrom et al., 2021). For more information about this scheme, see the ACLEW homepage. Speech by people other than the target child was transcribed using an adapted version of the CHAT transcription style (MacWhinney, 2019; Soderstrom et al., 2021). Because the majority of target children in the project are pre-lexical, utterances produced by the target child are not yet transcribed. Environmental speech was then classified by the addressee of each utterance: child, adult, both an adult and a child, pets or other animals, unclear addressee, or a recipient that doesn't fit into another category (e.g., voice control of Siri or Alexa, prayer to a metaphysical entity). All annotators are tested on the ACLEW scheme prior to beginning corpus annotation, until they reach 95% agreement or better with a "gold standard" coder for segmentation and utterance classification. Training often takes upwards of 20 hours of annotation practice. Following the first pass by annotators, all files were reviewed by a highly-trained "superchecker" to ensure consistency between coders and check for errors.

Extracting Measures of Language Input

To go from our dimensions of interest (quantity, interactiveness, linguistic, conceptual), to quantifiable properties, we used a combination of automated measures (generated by the proprietary LENA algorithm, Xu et al., 2009) and manual measures (generated from the transcriptions made by our trained annotators). Altogether, this corpus presently includes

approximately 453 hours of audio, 16240 utterances, and 67474 words; see Figure **??**. Quantity and interactiveness analyses were conducted on the random samples only, to capture a more representative estimate. Linguistic and conceptual analyses were conducted on all available annotations in order to maximize the amount of speech over which we could calculate them. These measures are described below and summarized in Table 2.

Quantity.

Automated Word Count.

To derive this count, the LENA algorithm segments the recording into clips which are then classified by speaker's gender (male/female), age (child/adult), and distance (near/far), as well as several non-human speaker categories (e.g., silence, electronic noise). Only segments that are classified as nearby male or female adult speech are included in the Adult Word Count estimation (Xu et al., 2009). Validation work suggests that this automated count correlates strongly with word counts derived from manual annotations (r = .71 − .92, Lehet, Arjmandi, Houston, & Dilley, 2021), and meta-analytic work finds that AWC is associated with children's language outcomes across developmental contexts (e.g., autism, hearing loss, Wang, Williams, Dilley, & Houston, 2020). Because the recordings varied in length (8 hours 17 minutes to 15 hours 59 minutes), we normalized AWC by dividing by recording length[2].

Manual Word Count.

We also calculated a manual count of speech in the children's environment. Manual Word Count (MWC) is simply the number of intelligible words in our transcriptions of each child's recording. Speech that was too far or muffled to be intelligible, as well as speech from the target child and electronic speech (TV, radio, toys) are excluded from this count. Unlike LENA's AWC, MWC contains speech from other speakers in the child's environment (e.g., siblings), not just from adults.

———

[2] To make these measures more comparable, we present both in terms of words per hour.

By using automated *and* manual measures of quantity, we hope to capture complementary estimates of the amount of speech children are exposed to. While AWC is considered less accurate than manual annotation (though highly correlated with it as noted above), it is commonly used, in part because of its strength in readily providing an estimate of the adult speech across the whole day. MWC, because it comes from human annotations, is the gold-standard for accurate speech estimates, but due to feasibility, is only derived from 30 minutes of the recording.

Interaction.

Conversational Turn Count.

One common metric of communicative interaction (e.g., Ganek & Eriks-Brophy, 2018; Magimairaj, Nagaraj, Caballero, Munoz, & White, 2022) is conversational turn count (or CTC), an automated measure generated by LENA (Xu et al., 2009). Like AWC, a recent meta-analysis finds that CTC is associated with children's language outcomes (Wang et al., 2020). After tagging vocalizations for speaker identity, the LENA algorithm looks for alternations between adult and target child speech in close temporal proximity (within 5 seconds). This can erroneously include non-contingent interactions (e.g., mom talking to dad while the infant babbles to herself nearby), and therefore inflate the count especially for younger ages and in houses with multiple children (Ferjan Ramírez, Hippe, & Kuhl, 2021). Still, this measure correlates moderately well with manually-coded conversational turns (Busch, Sangen, Vanpoucke, & van Wieringen, 2018; Ganek & Eriks-Brophy, 2018), and because participants in our sample are matched on both age and number of siblings, CTC overestimation should not be biased towards either group.

Proportion of Child-Directed Speech.

Our other measure of interaction is the proportion of utterances that are child-directed, derived from the manual annotations. Each proportion was calculated as the number of utterances (produced by someone *other* than the target child) tagged with a child as the

addressee, out of the total number of utterances.

Linguistic Features.

Type-Token Ratio.

As in previous work (Montag, Jones, & Smith, 2018; Pancsofar & Vernon-Feagans, 2006; e.g., Templin, 1957), we calculated the lexical diversity of the input by dividing the number of unique words by the total number of words (i.e., the type-token ratio). Because the type-token ratio changes as a function of the number of words in a sample (Montag et al., 2018; Richards, 1987), we first standardized the size of the sample by cutting the manual annotations in each recording into 100-word bins. We then calculated the type-token ratio within each of these bins by dividing the number of unique words in each bin by the number of total words (~100) and then averaged the type-token ratio across bins for each child. This provided a measure of lexical diversity: per 100 words, how many unique words are children exposed to?

MLU.

We also analyzed the syntactic complexity of children's language input, approximated as mean utterance length in morphemes. Each utterance in a child's input was tokenized into morphemes using the 'morphemepiece' R package (Bratt, Harmon, & Learning, 2022). We then calculated the mean length of utterance (number of morphemes) in each audio recording. We manually checked utterance length in a random subset of 10% of the utterances (n = 2826), which yielded a intra-class correlation coefficient of 0.94 agreement with the udpipe approach ($p < .001$), indicating high consistency.

Conceptual Features.   Our analysis of the conceptual features aims to measure whether the extent to which language input centers around the *"here and now"*: things that are currently present or occurring that a child may attend to in real time. We approximate *here-and-now*ness using lexical and morphosyntactic properties of the input.

Proportion of temporally displaced verbs.

We examined the displacement of events discussed in children's linguistic environment, via properties of the verbs in their input. Notably, we are attempting to highlight semantic features of the language environment. We do so here by categorizing utterances based the syntactic and morphological features of verbs, since these contain some time information in their surface forms. We assigned each utterance a **temporality** value: utterances tagged *displaced* describe events that take place in the past, future, or irrealis space, while utterances tagged *present* describe current, ongoing events. This coding scheme roughly aligns with both the temporal displacement and future hypothetical categories in Grimminger, Rohlfing, Lüke, Liszkowski, and Ritterfeld (2020; see also: Hudson, 2002; Lucariello and Nelson, 1987).

To do this, we used the udpipe package (Wijffels, 2023) to tag the transcriptions with parts of speech and other lexical features, such as tense, number agreement, or case inflection. To be marked as present, a verb either had to be marked with both present tense and indicative mood, or appear in the gerund form with no marked tense (e.g. *you talking to Papa?*). Features that could mark an utterance as displaced included past tense, presence of a modal, presence of *if*, or presence of *gonna/going to*, *have to*, *wanna/want to*, or *gotta/got to*, since these typically indicate future events, belief states and desires, rather than real-time events. In the case of utterances with multiple verbs, we selected the features from the first verb or auxiliary, as a proxy for hierarchical dominance. Utterances without verbs were excluded. A small number of verb-containing utterances in our corpus were left *ambiguous* (n = 1436/9111), either because they were fragments or because the automated parser failed to tag any of the relevant features. We manually checked verb temporality in a random subset of 10% of the utterances (n = 825); human judgments of event temporality aligned with the automated tense tagger 76% of the time (with the majority of discrepancies occurring on words the tagger categorized as ambiguous), indicating reasonably high reliability of this measure.

Proportion of highly visual words.

In addition to this general measure of decontextualized language, we include one measure that is uniquely decontextualized for blind children: the proportion of words in the input with referents that are highly and exclusively visual. We first filter the input to only content words (excluding, for example: the, at, of), using tidytext's stop_words function. We then categorize the perceptual modalities of words' referents using the Lancaster Sensorimotor Norms, ratings from typically-sighted adults about the extent to which a word evokes a visual/tactile/auditory/etc. experience (Lynott, Connell, Brysbaert, Brand, & Carney, 2020). Each word in the Lancaster Sensorimotor Norms (~40,000 English words) get a score for each of 6 sensory modalities (auditory, haptic, gustatory, interoceptive, olfactory, visual). Words with higher ratings in a given modality are more strongly associated with perceptual experience in that modality. A word's dominant perceptual modality is the modality which received the highest mean rating. We tweak this categorization in two ways: words which received low ratings across all modalities (all modalities rated less than <3.5./5) were re-categorized as *amodal*, and words whose ratings were distributed across modalities were re-categorized as *multimodal*[3]. Using this system, each of the content words in children's input were categorized into their primary perceptual modality; 74% of the words in our corpus had a corresponding word in the Lancaster ratings and could be categorized in this way. For each child, we extracted the proportion of exclusively "visual" words in their language environment.

———

[3] Words perceptual exclusivity scores of < 0.5/1 (calculated as a word's range of ratings across modalities divided by the sum of ratings across modalities, Lynott et al., 2020) were re-categorized as multimodal. The cut-offs for classifying amodal and multimodal words were chosen based on authors' intuitions regarding what thresholds seemed to classify the words well into amodal, multimodal, and visual phenomena. That said, results are robust across a range of thresholds, and all data are provided to interested readers should they be interested in considering other values.

Results

Measuring Properties of Language Input

Our study assesses whether language input to blind children is different from the language input to sighted children, along the dimensions of quantity, interaction, linguistic properties, and conceptual properties. We test for group differences using paired t-tests or non-parametric Wilcoxon signed rank tests, when a Shapiro-Wilks test indicates that the variable is not normally distributed (summarized in Table 2). Because this analysis involves multiple tests against the null hypothesis (*that there is no difference in the language input to blind vs. sighted kids*), we use the Benjamini-Hochberg correction (Benjamini & Hochberg, 1995) to control false discovery rate (Q = .05) for each set of analyses (quantity, interaction, linguistic, conceptual). Because each dimension's analysis consists of two statistical tests, our Benjamini-Hochberg critical values were $p < 0.025$ for the smaller p value and $p < 0.05$ for the larger p value. The results of these analyses are summarized in Table 2.

Language Input Quantity.   We first compare the quantity of language input to blind and sighted children using two measures of the number of words in their environment: LENA's automated Adult Word Count and our transcription-derived Manual Word Count. Despite wide variability in the number of words children hear (Range: 390–1984 words$_{\text{blind}}$, 475–1608 words$_{\text{sighted}}$ by LENA count), along both measures of input quantity, blind and sighted children do not differ in language input quantity (Adult Word Count: $t(14) = -0.02$, $p = .984$; Manual Word Count: $t(14) = 0.89$, $p = .387$); see Figure 2.

Interaction.   Our corpus also revealed no significant difference in amount of interaction with the child, measured as the proportion of child-directed speech ($t(14) = 0.07$, $p = .946$) or in conversational turn counts to blind children versus to sighted children ($W = 61$, $p = .978$). Across both groups, child-directed speech constituted approximately 57% of the input, and children were involved in roughly 34 conversational turns per hour.

Linguistic Features.   Both linguistic variables differed across groups: blind children had a significantly higher type-token ratio ($t(14) = -2.07$, $p = .058$), such that per 100 words,

blind children on average hear 2.07 more unique words than sighted children. Blind children also heard significantly longer MLU than to their sighted peers ($t(14) = -2.45$, $p = .028$), such that utterances in blind children's input were 0.66 morphemes longer; see Figure 4).

Conceptual Features. Lastly, we compared two measures of the conceptual features of language input: the proportion of temporally displaced verbs and the proportion of highly visual words. We found that blind children hear a higher proportion of displaced verbs than sighted children ($t(14) = -3.92$, $p = .002$), which on average equates to 26 more utterances about past, future, or hypothetical events per hour. We found no significant difference across groups in the proportion of highly visual words ($W = 63$, $p = .890$), which constitute roughly 11% of the input for both groups.

Discussion

This study, which contains more blind participants than prior research alongside a carefully peer-matched sighted sample, measured language input to young blind children and their sighted peers, using the LENA audio recorder. We found that along the dimensions of quantity and interaction, parents talk similarly to blind and sighted children, with differences in linguistic and conceptual content of the input. We discuss each of these results further below.

Quantity

Across two measures of language input quantity, one estimated from the full sixteen hour recording (Adult Word Count) and one precisely measured from a 30-minute window of that day (Manual Word Count), blind and sighted children were exposed to similar amounts of speech in the home. Quantity was highly variable *within* groups, but we found no evidence for *between* group differences in input quantity. This runs counter to two folk accounts of language input to blind children: 1) that sighted parents of blind children might talk *less* because they don't share visual common ground with their children; 2) that parents

of blind children might talk *more* to compensate for their children's lack of visual input. Instead, we find a similar quantity of speech across groups.

Interaction

We quantified interaction in two ways: through the LENA-estimated conversational turn count and through the proportion of child-directed speech in our manual annotations. Again, we found no differences across groups in the amount of parent-child interaction. This finding contrasts with previous research; other studies report *less* interaction in dyads where the child is blind (Pérez-Pereira & Conti-Ramsden, 2001; Charity Rowland, 1984; Andersen et al., 1993; Grumi et al., 2021; Kekelis & Andersen, 1984;, Moore & McConachie, 1994; Preisler, 1991). Using a non-visual sampling method (i.e., our audio recordings) might provide a different, more naturalistic perspective on parent-child interactions, particularly in this population. For one thing, many prior studies (e.g., Kekelis & Andersen, 1984; Moore & McConachie, 1994; Pérez-Pereira & Conti-Ramsden, 2001; Preisler, 1991) involve videorecordings in the child's home, with the researcher present. Like other young children, blind children distinguish between familiar individuals and strangers, and react with trepidation to the presence of a stranger; for blind children, this reaction may involve "quieting", wherein children cease speaking or vocalizing when they hear a new voice in the home (Fraiberg, 1975; McRae, 2002). By having a researcher present during the recordings[4] , prior research may have artificially suppressed blind children's initiation of interactions. Even naturalistic observer-free videorecordings appear to inflate aspects of parental input, relative to daylong audio recordings (Bergelson et al., 2019). Together, these factors could explain why past parent-child interaction research finds that blind children initiate fewer interactions (Andersen et al., 1993; Dote-Kwan, 1995; Kekelis & Andersen, 1984; Moore & McConachie, 1994; Tröster & Brambring, 1992), that parents do most of the talking (Andersen et al.,

———

[4] Fraiberg (1975) writes "these fear and avoidance behaviors appear even though the observer, a twice-monthly visitor, is not, strictly speaking, a stranger." (pg. 323).

1993; Kekelis & Andersen, 1984), and that there is overall less interaction (Nagayoshi et al., 2017; Rogers & Puchalski, 1984; Charity Rowland, 1984; Tröster & Brambring, 1992).

Additionally, a common focus in earlier interaction literature is to measure visual cues of interaction, such as shared gaze or attentiveness to facial expressions (Baird, Mayfield, & Baker, 1997; Preisler, 1991; Rogers & Puchalski, 1984). We can't help but wonder: are visual markers of social interaction the right yardstick to measure blind children against? In line with MacLeod and Demers (2023), perhaps the field should move away from sighted indicators of interaction "quality", and instead situate blind children's interactions within their own developmental niche, one that may be better captured with auditory- or tactile-focused measures.

Linguistic Features

Along the linguistic dimension, we measured type-token ratio and mean length of utterance. Parents of children with disabilities (including parents of blind children, e.g., Chernyak, n.d.; FamilyConnect, n.d.) are often advised to use shorter, simpler sentences with their children; correspondingly, previous work finds that parents of children with disabilities tend to find that parents *do* use shorter, simpler utterances (e.g., Down syndrome, Lorang, Venker, & Sterling, 2020; hearing loss, Dirks et al., 2020). We therefore expected to observe shorter utterances and less lexical diversity. Instead, we found that blind children heard on average 2.07 more unique words per hundred words and 0.66 more morphemes per utterance Hoff (2003). These results suggest that blind children are exposed to more lexically and morphosyntactically complex speech. Returning to the potential impact on children, evidence suggests that (contrary to the advice often given to parents), longer, more complex utterances are associated with better child language outcomes in both typically-developing children (Hoff & Naigles, 2002) and children with cognitive differences (Sandbank & Yoder, 2016). And similarly, higher lexical diversity is associated with larger vocabulary (Anderson et al., 2021; Hsu et al., 2017; Huttenlocher et al., 2010; Rowe, 2012;

Weizman & Snow, 2001). If these patterns are the same for blind children, this additional linguistic complexity may prove helpful in the absence of visual input.

Conceptual Features

Although there are many potential ways to measure the conceptual features of language, we chose to capture *here-and-now*-ness by measuring the proportion of temporally displaced verbs and the proportion of highly visual words. We found that blind children heard more temporally displaced verbs. Though blind and sighted participants were exposed to a similar proportion of highly visual words, the referents of these words are by definition, inaccessible to the blind participants. Taken together, our conceptual results suggest that blind children's input is *less* focused on their *here-and-now*.

The extent to which blind children's language input is centered on the *here-and-now* has been contested in the literature (Andersen et al., 1993; J. Campbell, 2003; Kekelis & Andersen, 1984; Moore & McConachie, 1994; Urwin, 1984). This aspect of language input is of particular interest because early reports suggest that blind children's own use of decontextualized language develops later than sighted children's (Bigelow, 1990; Urwin, 1984). Could this be related to an absence of decontextualized language in the input? Our sample says no: we find that blind children's input contains *more* decontextualized language. Because children have less access to immediate visual cues, caregivers might more frequently refer to past or future events to engage with their child. To illustrate, while riding on a train, instead of describing the scenery passing outside the window, parents may choose to talk about what happened earlier in the day or their plans upon arriving home. Without further information about the social and perceptual context, it is difficult to determine the communicative function of the differences we find in conceptual features we find or how they might explain differences in children's decontextualized language use. As more dense annotation becomes available, we can explore the social and environmental contexts of conceptual information as it unfolds across discourse.

We wish to highlight again how much variability there is *within* groups and how much consistency there is *between* groups. One could imagine a world in which the language environments of blind and sighted children are radically different from each other. Our data do not support that hypothesis. Rather, we find similarity in quantity and interaction, alongside modest differences in linguistic and conceptual properties. That is, in line with recent work highlighting immense *within*-group variability across many different socio-cultural and linguistic contexts (Bergelson et al., 2023), our blind and sighted groups here have large within-group variability but very few between-group differences. Despite strikingly different visual experiences, young blind and sighted learners have at best modest differences in the speech environments that surrounded them.

Connecting to Language Outcomes

Our results uncover no systematic group differences in the quantity of speech or the amount of language interaction parents provide to blind vs. sighted children. When we do see differences, language input to blind children looks more conceptually and linguistically complex. In other populations, complexity of this sort is linked with *more* sophisticated child language production, so it is not the case that blind children's language input is "impoverished".

In our predominantly pre-lexical sample, linking language input to children's language outcomes is not yet feasible, but prior literature allows us to speculate on the nature of this relationship. We explore two possibilities: First, if input effects pattern similarly for blind and sighted children, we would expect blind and sighted children alike to benefit from more input (Anderson et al., 2021; Gilkerson et al., 2018; Huttenlocher et al., 1991; Rowe, 2008), more interactive input Weisleder & Fernald (2013), more linguistically complex input (Anderson et al., 2021; De Villiers, 1985; Hadley et al., 2017; Hoff, 2003; Hsu et al., 2017; Huttenlocher et al., 2002, 2010; Naigles & Hoff-Ginsberg, 1998; Rowe, 2012; Weizman & Snow, 2001), and more conceptually complex input (Demir et al., 2015; Rowe, 2012; Uccelli

et al., 2019).

At the same time, however, recent results show that blind children have a roughly half-year delay in their productive vocabulary, relative to sighted peers (E. Campbell et al., 2024). This naturally leads to the question of whether language input may play a role in this delay: what if language input affects acquisition *differently* for blind children than it does for sighted children? Is it possible that blind children actually need *less* complex language, and that differences in the complexity of language input are responsible for early vocabulary delays?

To show our cards, we are inclined to believe the former account: that blind children benefit from receiving more complex language input. Language regularly supports learning in the absence of direct sensory perception (e.g., reading a book about mythical creatures). Given the language skills of blind adults (Loiotile et al., 2020; Röder et al., 2003; Röder et al., 2000), it seems likely that language is a source of meaning for blind individuals as well (E. E. Campbell & Bergelson, 2022; Lewis, Zettersten, & Lupyan, 2019; van Paridon, Liu, & Lupyan, 2021). Testing each of these predictions–as well as whether links between language input and language outcomes change across developmental time–awaits further research.

In either case, if properties of language input do influence blind children's language outcomes, attempting to train parents to talk differently may be unfruitful. Interventions where parents are trained to talk differently to their children often show short-term success (Roberts, Curtis, Sone, & Hampton, 2019) but fail to change parental speech patterns in the long term (e.g., McGillion, Pine, Herbert, & Matthews, 2017; Suskind et al., 2016).

Conclusion

In summary, our study compared language input in homes of 15 blind and 15 sighted infants. We found that both groups received similar quantities of adult speech and had similar levels of interaction. However, blind children were exposed to longer utterances and

more decontextualized language, suggesting that they are being exposed to a rich and complex linguistic environment that differs from the language input of sighted children. Our study does not imply that parents should change their communication styles, but rather highlights the unique language experiences of blind children. Future research should investigate how these input differences impact the language development and cognitive abilities of blind and sighted children alike.

Acknowledgements

References

Andersen, E. S., Dunlea, A., & Kekelis, L. (1993). The impact of input: Language acquisition in the visually impaired. *First Language*, *13*(37), 23–49. https://doi.org/10.1177/014272379301303703

Anderson, N. J., Graham, S. A., Prime, H., Jenkins, J. M., & Madigan, S. (2021). Linking Quality and Quantity of Parental Linguistic Input to Child Language Skills: A Meta-Analysis. *Child Development*, *92*(2), 484–501. https://doi.org/10.1111/cdev.13508

Baird, S. M., Mayfield, P., & Baker, P. (1997). Mothers' Interpretations of the Behavior of Their Infants with Visual and Other Impairments during Interactions. *Journal of Visual Impairment & Blindness*, *91*(5), 467–483. https://doi.org/10.1177/0145482X9709100507

Benjamini, Y., & Hochberg, Y. (1995). Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. *Journal of the Royal Statistical Society. Series B (Methodological)*, *57*(1), 289–300. Retrieved from https://www.jstor.org/stable/2346101

Bergelson, E. (2015). Bergelson Seedlings HomeBank Corpus. TalkBank. https://doi.org/10.21415/T5PK6D

Bergelson, E., Amatuni, A., Dailey, S., Koorathota, S., & Tor, S. (2019). Day by day, hour by hour: Naturalistic language input to infants. *Developmental Science*, *22*(1), e12715. https://doi.org/10.1111/desc.12715

Bergelson, E., Soderstrom, M., Schwarz, I.-C., Rowland, C. F., Ramírez-Esparza, N., R. Hamrick, L., . . . Cristia, A. (2023). Everyday language input and production in 1,001 children from six continents. *Proceedings of the National Academy of Sciences*, *120*(52), e2300671120. https://doi.org/10.1073/pnas.2300671120

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

Bernstein Ratner, N. (1984). Patterns of vowel modification in mother–child speech. *Journal of Child Language*, *11*, 557–578.

Bigelow, A. (1987). Early words of blind children. *Journal of Child Language*, *14*(1), 47–56. https://doi.org/10.1017/S0305000900012721

Bigelow, A. (1990). Relationship between the Development of Language and Thought in Young Blind Children. *Journal of Visual Impairment & Blindness*, *84*(8), 414–419. https://doi.org/10.1177/0145482X9008400805

Bratt, J., Harmon, J., & Learning, B. F. &. W. P. G. L. D. M. (2022). Morphemepiece: Morpheme Tokenization.

Brugman, H., & Russel, A. (2009). Annotating Multimedia / Multi-modal resources with ELAN. *Proceedings of the Fourth International Conference on Language Resources and Evaluation.*

Busch, T., Sangen, A., Vanpoucke, F., & van Wieringen, A. (2018). Correlation and agreement between Language ENvironment Analysis (LENA™) and manual transcription for Dutch natural language recordings. *Behavior Research Methods*, *50*(5), 1921–1932. https://doi.org/10.3758/s13428-017-0960-0

Campbell, E. E., & Bergelson, E. (2022). Making sense of sensory language: Acquisition of sensory knowledge by individuals with congenital sensory impairments. *Neuropsychologia*,

174, 108320. https://doi.org/10.1016/j.neuropsychologia.2022.108320

Campbell, E., Casillas, R., & Bergelson, E. (2024). The role of vision in the acquisition of words: Vocabulary development in blind toddlers. *Developmental Science*, *n/a*(n/a), e13475. https://doi.org/10.1111/desc.13475

Campbell, J. (2003). Maternal Directives to Young Children who are Blind. *Journal of Visual Impairment & Blindness*, *97*(6), 355–365. https://doi.org/10.1177/0145482X0309700604

Casillas, M., Brown, P., & Levinson, S. C. (2020). Early Language Experience in a Tseltal Mayan Village. *Child Development*, *91*(5), 1819–1835. https://doi.org/10.1111/cdev.13349

Chernyak, P. (n.d.). 3 Ways to Teach Your Blind or Visually Impaired Child to Talk. *WikiHow.*
https://www.wikihow.life/Teach-Your-Blind-or-Visually-Impaired-Child-to-Talk.

Chiesa, S., Galati, D., & Schmidt, S. (2015). Communicative interactions between visually impaired mothers and their sighted children: Analysis of gaze, facial expressions, voice and physical contacts. *Child: Care, Health and Development*, *41*(6), 1040–1046. https://doi.org/10.1111/cch.12274

De Villiers, J. (1985). Learning how to use verbs: Lexical coding and the influence of the input*. *Journal of Child Language*, *12*(3), 587–595. https://doi.org/10.1017/S0305000900006668

Demir, Ö. E., Rowe, M. L., Heller, G., Goldin-Meadow, S., & Levine, S. C. (2015). Vocabulary, syntax, and narrative development in typically developing children and children with early unilateral brain injury: Early parental talk about the "there-and-then" matters. *Developmental Psychology*, *51*(2), 161–175. https://doi.org/10.1037/a0038476

Dirks, E., Stevens, A., Kok, S., Frijns, J., & Rieffe, C. (2020). Talk with me! Parental linguistic input to toddlers with moderate hearing loss. *Journal of Child Language*, *47*(1), 186–204. https://doi.org/10.1017/S0305000919000667

Donnellan, E., Bannard, C., McGillion, M. L., Slocombe, K. E., & Matthews, D. (2020). Infants' intentionally communicative vocalizations elicit responses from caregivers and are the best predictors of the transition to language: A longitudinal investigation of infants' vocalizations, gestures and word production. *Developmental Science, 23*(1), e12843. https://doi.org/10.1111/desc.12843

Dote-Kwan, J. (1995). Impact of Mothers' Interactions on the Development of Their Young Visually Impaired Children. *Journal of Visual Impairment & Blindness, 89*(1), 46–58. https://doi.org/10.1177/0145482X9508900109

FamilyConnect. (n.d.). Understanding the Stages of Language Development for Babies Who Are Blind. *FamilyConnect.*

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., . . . Stiles, J. (1994). Variability in Early Communicative Development. *Monographs of the Society for Research in Child Development, 59*(5), i. https://doi.org/10.2307/1166093

Ferjan Ramírez, N., Hippe, D. S., & Kuhl, P. K. (2021). Comparing Automatic and Manual Measures of Parent–Infant Conversational Turns: A Word of Caution. *Child Development, 92*(2), 672–681. https://doi.org/10.1111/cdev.13495

Fernald, A. (1989). Intonation and communicative intent in mothers' speech to infants: Is the melody the message? *Child Development, 60*(6), 1497–1510.

Fernald, A., & Morikawa, H. (1993). Common themes and cultural variations in Japanese and American mothers' speech to infants. *Child Development, 64*(3), 637–656.

Fraiberg, S. (1975). The development of human attachments in infants blind from birth. *Merrill-Palmer Quarterly, 21*, 315–334.

Ganea, N., Hudry, K., Vernetti, A., Tucker, L., Charman, T., Johnson, M. H., & Senju, A. (2018). Development of adaptive communication skills in infants of blind parents. *Developmental Psychology, 54*(12), 2265–2273. https://doi.org/10.1037/dev0000564

Ganek, H., & Eriks-Brophy, A. (2016). The Language ENvironment Analysis (LENA) system: A literature review. In *Proceedings of the joint workshop on NLP for Computer*

Assisted Language Learning and NLP for Language Acquisition (pp. 24–32). Umeå, Sweden: LiU Electronic Press.

Ganek, H., & Eriks-Brophy, A. (2018). Language ENvironment analysis (LENA) system investigation of day long recordings in children: A literature review. *Journal of Communication Disorders*, *72*, 77–85. https://doi.org/10.1016/j.jcomdis.2017.12.005

Gergle, D., Kraut, R. E., & Fussell, S. R. (2004). Language Efficiency and Visual Technology: Minimizing Collaborative Effort with Visual Information. *Journal of Language and Social Psychology*, *23*(4), 491–517. https://doi.org/10.1177/0261927X04269589

Gilkerson, J., & Richards, J. A. (2008). *The LENA Natural Language Study.* Boulder, CO: LENA Foundation.

Gilkerson, J., Richards, J. A., Warren, S. F., Oller, D. K., Russo, R., & Vohr, B. (2018). Language Experience in the Second Year of Life and Language Outcomes in Late Childhood. *Pediatrics*, *142*(4), e20174276. https://doi.org/10.1542/peds.2017-4276

Gleitman, L. (1990). The Structural Sources of Verb Meanings. *Language Acquisition*, *1*(1), 3–55. Retrieved from https://www.jstor.org/stable/20011341

Goldstein, M. H., & Schwade, J. A. (2008). Social feedback to infants' babbling facilitates rapid phonological learning. *Psychological Science*, *19*(5), 515–523. https://doi.org/10.1111/j.1467-9280.2008.02117.x

Grice, H. P. (1975). Logic and Conversation. In *Syntax and semantics.* New York San Francisco London: Academic press, Harcourt Brace Jovanovich.

Grigoroglou, M., Edu, U., & Papafragou, A. (2016). Are children flexible speakers? Effects of typicality and listener needs in children's event descriptions. *Cognitive Science*, 6.

Grimminger, A., Rohlfing, K. J., Lüke, C., Liszkowski, U., & Ritterfeld, U. (2020). Decontextualized talk in caregivers' input to 12-month-old children during structured interaction. *Journal of Child Language*, *47*(2), 418–434. https://doi.org/10.1017/S0305000919000710

Grumi, S., Cappagli, G., Aprile, G., Mascherpa, E., Gori, M., Provenzi, L., & Signorini, S.

(2021). Togetherness, beyond the eyes: A systematic review on the interaction between visually impaired children and their parents. *Infant Behavior and Development*, *64*, 101590. https://doi.org/10.1016/j.infbeh.2021.101590

Hadley, P. A., Rispoli, M., Holt, J. K., Papastratakos, T., Hsu, N., Kubalanza, M., & McKenna, M. M. (2017). Input Subject Diversity Enhances Early Grammatical Growth: Evidence from a Parent-Implemented Intervention. *Language Learning and Development: The Official Journal of the Society for Language Development*, *13*(1), 54–79. https://doi.org/10.1080/15475441.2016.1193020

Hawkins, R. D., Gweon, H., & Goodman, N. D. (2021). The Division of Labor in Communication: Speakers Help Listeners Account for Asymmetries in Visual Perspective. *Cognitive Science*, *45*(3), e12926. https://doi.org/10.1111/cogs.12926

Hazan, V., & Baker, R. (2011). Acoustic-phonetic characteristics of speech produced with communicative intent to counter adverse listening conditions. *The Journal of the Acoustical Society of America*, *130*(4), 2139–2152. https://doi.org/10.1121/1.3623753

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., . . . Suma, K. (2015). The Contribution of Early Communication Quality to Low-Income Children's Language Success. *Psychological Science*, *26*(7), 1071–1083. https://doi.org/10.1177/0956797615581493

Hoff, E. (2003). The specificity of environmental influence: Socioeconomic status affects early vocabulary development via maternal speech. *Child Development*, *74*(5), 1368–1378. https://doi.org/10.1111/1467-8624.00612

Hoff, E., & Naigles, L. (2002). How children use input to acquire a lexicon. *Child Development*, *73*(2), 418–433. https://doi.org/10.1111/1467-8624.00415

Hsu, N., Hadley, P. A., & Rispoli, M. (2017). Diversity matters: Parent input predicts toddler verb production. *Journal of Child Language*, *44*(1), 63–86. https://doi.org/10.1017/S0305000915000690

Hudson, J. A. (2002). "Do You Know What We're Going to Do This Summer?": Mothers'

Talk to Preschool Children About Future Events. *Journal of Cognition and Development*, *3*(1), 49–71. https://doi.org/10.1207/S15327647JCD0301_4

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology*, *27*, 236–248. https://doi.org/10.1037/0012-1649.27.2.236

Huttenlocher, J., Vasilyeva, M., Cymerman, E., & Levine, S. (2002). Language input and child syntax. *Cognitive Psychology*, *45*(3), 337–374. https://doi.org/10.1016/s0010-0285(02)00500-5

Huttenlocher, J., Waterfall, H., Vasilyeva, M., Vevea, J., & Hedges, L. V. (2010). Sources of variability in children's language growth. *Cognitive Psychology*, *61*(4), 343–365. https://doi.org/10.1016/j.cogpsych.2010.08.002

Jara-Ettinger, J., & Rubio-Fernandez, P. (2021). The social basis of referential communication: Speakers construct physical reference based on listeners' expected visual search. *Psychological Review*, No Pagination Specified–No Pagination Specified. https://doi.org/10.1037/rev0000345

Kekelis, L. S., & Andersen, E. S. (1984). Family Communication Styles and Language Development. *Journal of Visual Impairment & Blindness*, *78*(2), 54–65. https://doi.org/10.1177/0145482X8407800202

Kramer, J. A., Hill, K. T., & Cohen, L. B. (1975). Infants' Development of Object Permanence: A Refined Methodology and New Evidence for Piaget's Hypothesized Ordinality. *Child Development*, *46*(1), 149–155. https://doi.org/10.2307/1128843

Landau, B., & Gleitman, L. R. (1985). *Language and experience: Evidence from the blind child* (pp. xi, 250). Cambridge, MA, US: Harvard University Press.

Lavechin, M., Bousbib, R., Bredin, H., Dupoux, E., & Cristia, A. (2021). An open-source voice type classifier for child-centered daylong recordings. arXiv. https://doi.org/10.48550/arXiv.2005.12656

Lehet, M., Arjmandi, M. K., Houston, D., & Dilley, L. (2021). Circumspection in using

automated measures: Talker gender and addressee affect error rates for adult speech detection in the Language ENvironment Analysis (LENA) system. *Behavior Research Methods*, *53*(1), 113–138. https://doi.org/10.3758/s13428-020-01419-y

Lewis, M., Zettersten, M., & Lupyan, G. (2019). Distributional semantics as a source of visual knowledge. *Proceedings of the National Academy of Sciences*, *116*(39), 19237–19238. https://doi.org/10.1073/pnas.1910148116

Loiotile, R., Lane, C., Omaki, A., & Bedny, M. (2020). Enhanced performance on a sentence comprehension task in congenitally blind adults. *Language, Cognition and Neuroscience*, *35*(8), 1010–1023. https://doi.org/10.1080/23273798.2019.1706753

Lorang, E., Venker, C. E., & Sterling, A. (2020). An investigation into maternal use of telegraphic input to children with Down syndrome. *Journal of Child Language*, *47*(1), 225–249. https://doi.org/10.1017/S0305000919000503

Lucariello, J., & Nelson, K. (1987). Remembering and planning talk between mothers and children. *Discourse Processes*, *10*(3), 219–235. https://doi.org/10.1080/01638538709544673

Lucca, K., & Wilbourn, M. P. (2018). Communicating to Learn: Infants' Pointing Gestures Result in Optimal Learning. *Child Development*, *89*(3), 941–960. https://doi.org/10.1111/cdev.12707

Luchkina, E., Xu, F., Sobel, D., & Morgan, J. (2020). *Sixteen-month-olds comprehend unanchored absent reference* (Preprint). Open Science Framework. https://doi.org/10.31219/osf.io/5tc6d

Lynott, D., Connell, L., Brysbaert, M., Brand, J., & Carney, J. (2020). The Lancaster Sensorimotor Norms: Multidimensional measures of perceptual and action strength for 40,000 English words. *Behavior Research Methods*, *52*(3), 1271–1291. https://doi.org/10.3758/s13428-019-01316-z

MacLeod, A. A. N., & Demers, C. (2023). Transmitting white monolingual Anglo-American norms: A concept analysis of "quality of language" in parent-child interactions. *Applied*

Psycholinguistics, 1–29. https://doi.org/10.1017/S014271642300005X

MacWhinney, B. (2019). CHAT Manual. https://doi.org/10.21415/3MHN-0Z89

Magimairaj, B., Nagaraj, N., Caballero, A., Munoz, K., & White, K. (2022). A Systematic
    Review of the Effects of LENA-based Feedback on Parent-Child Language Interactions in
    Families with Young Children. *Journal of Early Hearing Detection and Intervention*,
    7(3), 47–60. https://doi.org/10.26077/6c72-973b

McGillion, M., Pine, J. M., Herbert, J. S., & Matthews, D. (2017). A randomised controlled
    trial to test the effect of promoting caregiver contingent talk on language development in
    infants from diverse socioeconomic status backgrounds. *Journal of Child Psychology and
    Psychiatry*, *58*(10), 1122–1131. https://doi.org/10.1111/jcpp.12725

McRae, K. A. (2002). *Attachment in blind infants : A systematic investigation using
    Ainsworth's Strange Situation.* (PhD thesis). University of Toronto, Toronto, Canada.

Montag, J. L., Jones, M. N., & Smith, L. B. (2018). Quantity and Diversity: Simulating
    Early Word Learning Environments. *Cognitive Science*, *42 Suppl 2*(Suppl 2), 375–412.
    https://doi.org/10.1111/cogs.12592

Moore, V., & McConachie, H. (1994). Communication between blind and severely visually
    impaired children and their parents. *British Journal of Developmental Psychology*, *12*(4),
    491–502. https://doi.org/10.1111/j.2044-835X.1994.tb00650.x

Moser, C., Lee-Rubin, H., Bainbridge, C., Atwood, S., Simson, J., Knox, D., . . . Mehr, S.
    (2022). Acoustic regularities in infant-directed vocalizations across cultures. *Nature
    Human Behavior*, *6*(11), 1545–1556. https://doi.org/doi: 10.1038/s41562-022-01410-x

Nagayoshi, M., Hirose, T., Toju, K., Suzuki, S., Okamitsu, M., Teramoto, T., . . . Takeo, N.
    (2017). Related visual impairment to mother-infant interaction and development in
    infants with bilateral retinoblastoma. *European Journal of Oncology Nursing: The
    Official Journal of European Oncology Nursing Society*, *28*, 28–34.
    https://doi.org/10.1016/j.ejon.2017.02.002

Naigles, L. R., & Hoff-Ginsberg, E. (1998). Why are some verbs learned before other verbs?

Effects of input frequency and structure on children's early verb use. *Journal of Child Language*, *25*(1), 95–120. https://doi.org/10.1017/S0305000997003358

Ostarek, M., Paridon, J. van, & Montero-Melis, G. (2019). Sighted people's language is not helpful for blind individuals' acquisition of typical animal colors. *Proceedings of the National Academy of Sciences*, *116*(44), 21972–21973. https://doi.org/10.1073/pnas.1912302116

Pancsofar, N., & Vernon-Feagans, L. (2006). Mother and father language input to young children: Contributions to later language development. *Journal of Applied Developmental Psychology*, *27*(6), 571–587. https://doi.org/10.1016/j.appdev.2006.08.003

Pérez-Pereira, M., & Conti-Ramsden, G. (2001). The use of Directives in Verbal Interactions between Blind Children and their Mothers. *Journal of Visual Impairment & Blindness*, *95*(3), 133–149. https://doi.org/10.1177/0145482x0109500302

Pisani, S., Gautheron, L., & Cristia, A. (2021). *Long-form recordings: From A to Z.*

Preisler, G. M. (1991). Early patterns of interaction between blind infants and their sighted mothers. *Child: Care, Health and Development*, *17*(2), 65–90. https://doi.org/10.1111/j.1365-2214.1991.tb00680.x

Ramírez-Esparza, N., García-Sierra, A., & Kuhl, P. K. (2014). Look who's talking: Speech style and social context in language input to infants are linked to concurrent and future speech development. *Developmental Science*, *17*(6), 880–891. https://doi.org/10.1111/desc.12172

Richards, B. (1987). Type/Token Ratios: What do they really tell us? *Journal of Child Language*, *14*(2), 201. https://doi.org/doi:10.1017/s0305000900012885

Roberts, M. Y., Curtis, P. R., Sone, B. J., & Hampton, L. H. (2019). Association of Parent Training With Child Language Development: A Systematic Review and Meta-analysis. *JAMA Pediatrics*, *173*(7), 671–680. https://doi.org/10.1001/jamapediatrics.2019.1197

Röder, B., Demuth, L., Streb, J., & Rösler, F. (2003). Semantic and morpho-syntactic priming in auditory word recognition in congenitally blind adults. *Language and*

Cognitive Processes, *18*(1), 1–20. https://doi.org/10.1080/01690960143000407

Röder, B., Rösler, F., & Neville, H. J. (2000). Event-related potentials during auditory
language processing in congenitally blind and sighted people. *Neuropsychologia*, *38*(11),
1482–1502. https://doi.org/10.1016/S0028-3932(00)00057-9

Rogers, S. J., & Puchalski, C. B. (1984). Social Characteristics of Visually Impaired Infants'
Play. *Topics in Early Childhood Special Education*, *3*(4), 52–56.
https://doi.org/10.1177/027112148400300409

Romeo, R. R., Leonard, J. A., Robinson, S. T., West, M. R., Mackey, A. P., Rowe, M. L., &
Gabrieli, J. D. E. (2018). Beyond the 30-Million-Word Gap: Children's Conversational
Exposure Is Associated With Language-Related Brain Function. *Psychological Science*,
29(5), 700–710. https://doi.org/10.1177/0956797617742725

Rowe, M. L. (2008). Child-directed speech: Relation to socioeconomic status, knowledge of
child development and child vocabulary skill*. *Journal of Child Language*, *35*(1),
185–205. https://doi.org/10.1017/S0305000907008343

Rowe, M. L. (2012). A Longitudinal Investigation of the Role of Quantity and Quality of
Child-Directed Speech in Vocabulary Development. *Child Development*, *83*(5),
1762–1774. https://doi.org/10.1111/j.1467-8624.2012.01805.x

Rowe, M. L. (2013). Decontextualized Language Input and Preschoolers' Vocabulary
Development. *Seminars in Speech and Language*, *34*(4), 260–266.
https://doi.org/10.1055/s-0033-1353444

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

Rowland, Charity. (1984). Preverbal Communication of Blind Infants and Their Mothers.
Journal of Visual Impairment & Blindness, *78*(7), 297–302.
https://doi.org/10.1177/0145482X8407800701

Rowland, Caroline, Durrant, S., Peter, M., Bidgood, A., Pine, J., & Jago, L. S. (2018). The

Language 0-5 Project. https://doi.org/10.17605/OSF.IO/KAU5F

Rubio-Fernandez, P. (2019). Overinformative Speakers Are Cooperative: Revisiting the
Gricean Maxim of Quantity. *Cognitive Science*, *43*(11), e12797.
https://doi.org/10.1111/cogs.12797

Sandbank, M., & Yoder, P. (2016). The Association Between Parental Mean Length of
Utterance and Language Outcomes in Children With Disabilities: A Correlational
Meta-Analysis. *American Journal of Speech-Language Pathology*, *25*(2), 240–251.
https://doi.org/10.1044/2015_AJSLP-15-0003

Senju, A., Tucker, L., Pasco, G., Hudry, K., Elsabbagh, M., Charman, T., & Johnson, M. H.
(2013). The importance of the eyes: Communication skills in infants of blind parents.
Proceedings. Biological Sciences, *280*(1760), 20130436.
https://doi.org/10.1098/rspb.2013.0436

Shneidman, L. A., Arroyo, M. E., Levine, S. C., & Goldin-Meadow, S. (2013). What counts
as effective input for word learning? *Journal of Child Language*, *40*(3), 672–686.
https://doi.org/10.1017/S0305000912000141

Snow, C. E. (1972). Mothers' Speech to Children Learning Language on JSTOR. *Child
Development*, *43*, 549–565.

Soderstrom, M., Casillas, M., Bergelson, E., Rosemberg, C., Alam, F., Warlaumont, A. S., &
Bunce, J. (2021). Developing a Cross-Cultural Annotation System and MetaCorpus for
Studying Infants' Real World Language Experience. *Collabra: Psychology*, *7*(1), 23445.
https://doi.org/10.1525/collabra.23445

Suskind, D. L., Leffel, K. R., Graf, E., Hernandez, M. W., Gunderson, E. A., Sapolich, S. G.,
. . . Levine, S. C. (2016). A parent-directed language intervention for children of low
socioeconomic status: A randomized controlled pilot study. *Journal of Child Language*,
43(2), 366–406. https://doi.org/10.1017/S0305000915000033

Tadić, V., Pring, L., & Dale, N. (2013). Story discourse and use of mental state language
between mothers and school-aged children with and without visual impairment.

International Journal of Language & Communication Disorders, *48*(6), 679–688.
https://doi.org/10.1111/1460-6984.12040

Templin, M. C. (1957). *Certain language skills in children; their development and interrelationships* (pp. xviii, 183). Minneapolis, MN, US: University of Minnesota Press.

Thiessen, E. D., Hill, E. A., & Saffran, J. R. (2005). Infant-Directed Speech Facilitates Word Segmentation. *Infancy: The Official Journal of the International Society on Infant Studies*, *7*(1), 53–71. https://doi.org/10.1207/s15327078in0701_5

Tomasello, M., & Farrar, M. J. (1986). Joint Attention and Early Language. *Child Development*, *57*(6), 1454. https://doi.org/10.2307/1130423

Tröster, H., & Brambring, M. (1992). Early social-emotional development in blind infants. *Child: Care, Health and Development*, *18*(4), 207–227. https://doi.org/10.1111/j.1365-2214.1992.tb00355.x

Uccelli, P., Demir-Lira, Ö. E., Rowe, M. L., Levine, S., & Goldin-Meadow, S. (2019). Children's Early Decontextualized Talk Predicts Academic Language Proficiency in Midadolescence. *Child Development*, *90*(5), 1650–1663. https://doi.org/10.1111/cdev.13034

Urwin, C. (1983). Dialogue and cognitive functioning in the early language development of three blind children: Normal and deficient, 142–161.

Urwin, C. (1984). Language for absent things: Learning from visually handicapped children. *Topics in Language Disorders*, *4*(4), 24.

van Paridon, J., Liu, Q., & Lupyan, G. (2021). How do blind people know that blue is cold? Distributional semantics encode color-adjective associations. PsyArXiv. https://doi.org/10.31234/osf.io/vyxpq

VanDam, M., Oller, D. K., Ambrose, S. E., Gray, S., Richards, J. A., Xu, D., ... Moeller, M. P. (2015). Automated Vocal Analysis of Children with Hearing Loss and Their Typical and Atypical Peers. *Ear and Hearing*, *36*(4), e146–e152. https://doi.org/10.1097/AUD.0000000000000138

VanDam, M., Warlaumont, A. S., Bergelson, E., Cristia, A., Soderstrom, M., Palma, P. D., & MacWhinney, B. (2016). HomeBank: An Online Repository of Daylong Child-Centered Audio Recordings. *Seminars in Speech and Language*, *37*(02), 128–142. https://doi.org/10.1055/s-0036-1580745

Vygotsky, L. S., & Cole, M. (1978). *Mind in Society: Development of Higher Psychological Processes*. Harvard University Press.

Wang, Y., Cooke, M., Reed, J., Dilley, L., & Houston, D. M. (2022). Home Auditory Environments of Children With Cochlear Implants and Children With Normal Hearing. *Ear and Hearing*, *43*(2), 592. https://doi.org/10.1097/AUD.0000000000001124

Wang, Y., Williams, R., Dilley, L., & Houston, D. M. (2020). A meta-analysis of the predictability of LENA™ automated measures for child language development. *Developmental Review*, *57*, 100921. https://doi.org/10.1016/j.dr.2020.100921

Warlaumont, A. S., Pretzer, G. M., Mendoza, S., & Walle, E. A. (2016). Warlaumont HomeBank Corpus. TalkBank. https://doi.org/10.21415/T54S3C

Watkins, S., Pittman, P., & Walden, B. (1998). The Deaf Mentor Experimental Project for young children who are deaf and their families. *American Annals of the Deaf*, *143*(1), 29–34. https://doi.org/10.1353/aad.2012.0098

Weisleder, A., & Fernald, A. (2013). Talking to Children Matters: Early Language Experience Strengthens Processing and Builds Vocabulary. *Psychological Science*, *24*(11), 2143–2152. https://doi.org/10.1177/0956797613488145

Weizman, Z. O., & Snow, C. E. (2001). Lexical input as related to children's vocabulary acquisition: Effects of sophisticated exposure and support for meaning. *Developmental Psychology*, *37*(2), 265–279. https://doi.org/10.1037/0012-1649.37.2.265

Wijffels, J. (2023). UDPipe.

Xu, D., Yapanel, U., & Gray, S. (2009). *Reliability of the LENA Language Environment Analysis System in Young Children's Natural Home Environment* (pp. 1–16). Boulder, CO: The LENA Foundation.

Yoshinaga-Itano, C., Sedey, A. L., Mason, C. A., Wiggin, M., & Chung, W. (2020). Early
    Intervention, Parent Talk, and Pragmatic Language in Children With Hearing Loss.
    Pediatrics, *146*(Supplement_3), S270–S277. https://doi.org/10.1542/peds.2020-0242F

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

Table 1

Demographic characteristics of the blind and sighted samples. For continuous variables, range and mean are provided. For categorical variables, percentages by level are provided.

Variable	Blind (N=15)	Sighted (N=15)
Age (months)	6–30, 15.8 (8.2)	6–32, 16.1 (8.1)
Sex	Female: 44%	Female: 44%
	Male: 56%	Male: 56%
Number of Older Siblings	0–2, 0.5 (0.8)	0–3, 1.1 (1)
Race	American Indian or Alaska Native: 6%	American Indian or Alaska Native: 0%
	Black or African American: 6%	Black or African American: 6%
	Mixed: 19%	Mixed: 6%
	White: 69%	White: 44%
	unknown: 0%	unknown: 44%
Maternal Education	Some college: 19%	Some college: 6%
	Associate's degree: 6%	Associate's degree: 12%
	Bachelor's degree: 31%	Bachelor's degree: 56%
	Graduate degree: 44%	Graduate degree: 6%
Ethnicity	Hispanic or Latino: 19%	Hispanic or Latino: 0%
	Not Hispanic or Latino: 81%	Not Hispanic or Latino: 50%
	unknown: 0%	unknown: 50%

Table 2

Summary of language input variables: how the measure is calculated; what portion of the recording the measure was calculated over; whether a parametric or non-parametric test was used; the mean, median, and range for blind and sighted children, and the raw (uncorrected) p-value of the test comparing groups.

| Variable	Description	Portion of Recording	Test	Blind Mean, Median, Range	Sighted Mean, Median, Range	p value
Adult Word Count	Estimated number of words in recording categorized as nearby adult speech by LENA algorithm	Whole day	t-test	2124, 1808, 779-3968 words/hour	2117, 2047, 951-3216 words/hour	.984
Manual Word Count	Number of word tokens from speakers other than target child	Random	t-test	4122, 4100, 1204-7260 words/hour	4626, 4340, 764-8356 words/hour	.387
Conversational Turn Count	Count of temporally close switches between adult and target-child vocalizations, divided by recording length	Whole day	Wilcoxon test	66, 49, 26-180 turns/hour	71, 65, 18-169 turns/hour	.946
Prop. Child-Directed Speech	Number of utterances tagged with child addressee out of total number of utterances, from speakers other than target child	Random	t-test	0.57, 0.61, 0.23-1	0.57, 0.57, 0.1-0.95	.978
Type-Token Ratio	Average of the type-token ratios (number of unique words divided by number of total words) for each of the 100-word bins in their sample	Random + High Volume	t-test	0.65, 0.65, 0.6-0.67 unique words/ 100 words	0.63, 0.62, 0.55-0.69 unique words/ 100 words	.058
Mean Length of Utterance	Average number of morphemes per utterance	Random + High Volume	t-test	5.89, 5.64, 4.33-8.05 morphemes	5.23, 5.39, 4.35-6.14 morphemes	.028*
Prop. Displaced	Proportion of verbs that refer to past, future, or hypothetical events	Random + High Volume	t-test	0.35, 0.37, 0.24-0.43	0.29, 0.29, 0.13-0.39	.002*
Prop. Visual	Proportion of words in the input with high visual association ratings and low ratings for other perceptual modalities	Random + High Volume	Wilcoxon test	0.11, 0.09, 0.04-0.21	0.11, 0.1, 0.06-0.22	.890
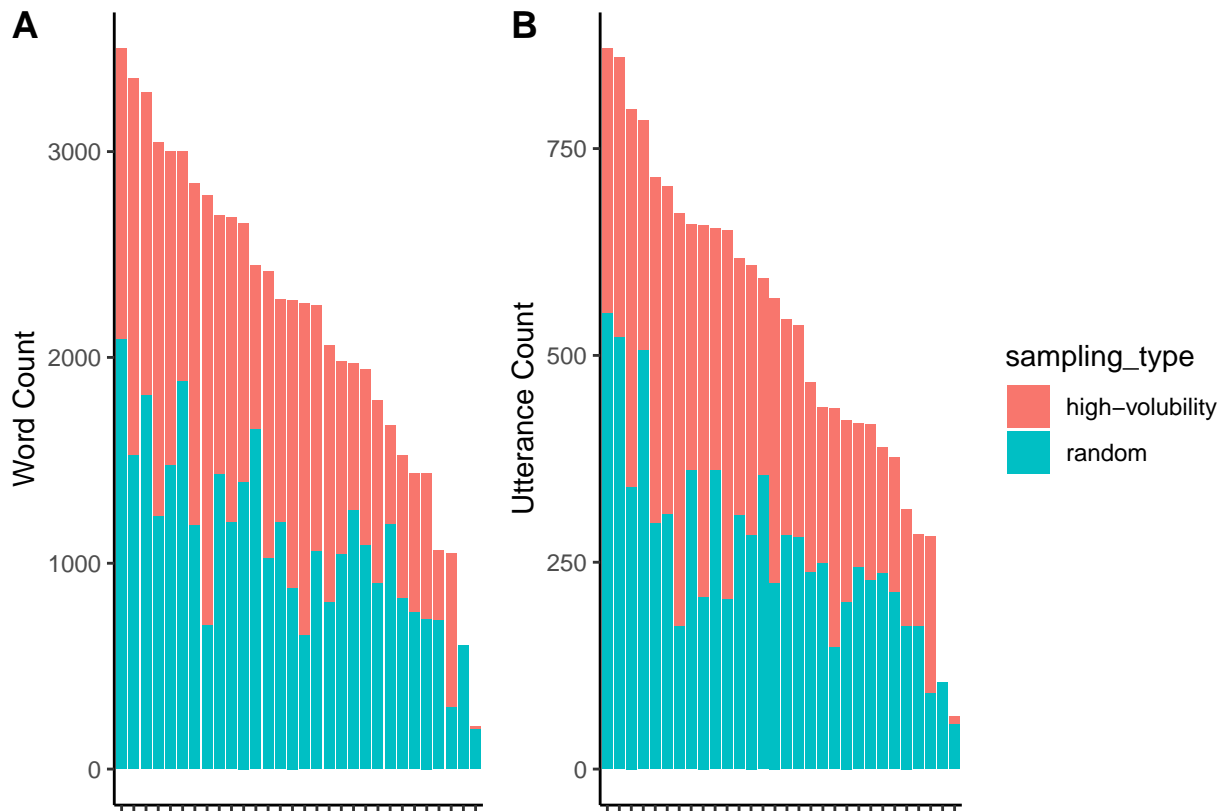
Figure 1. The amount of text that analyses are run over. Left panel shows the corpus size in words, and right panel shows the corpus size in utterances. Each bar shows the amount of speech in one child's recording, colored by whether the words/utterances were in random or high-volubility samples.
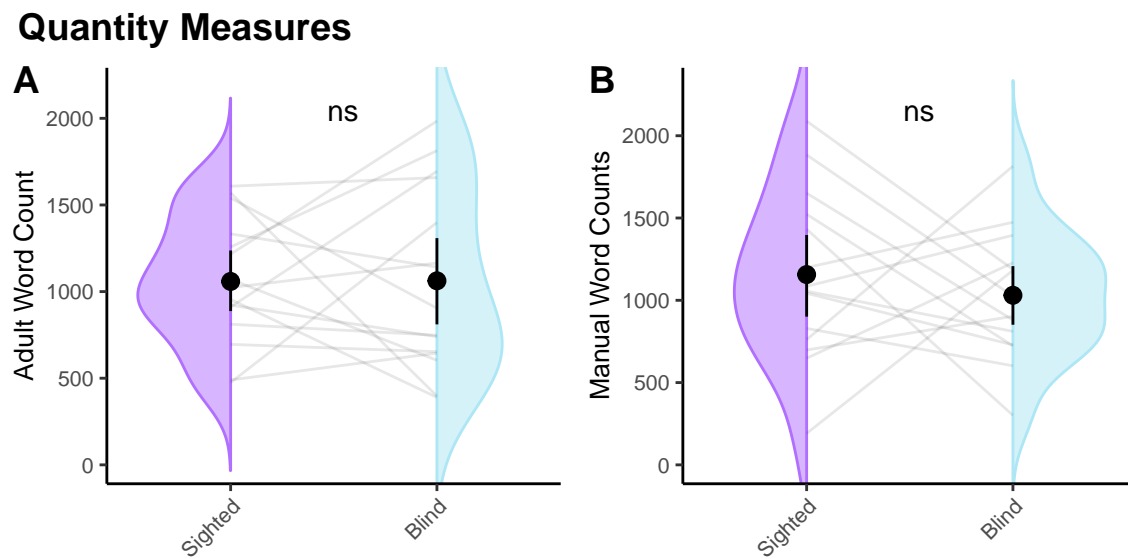
Quantity Measures

Figure 2. Comparing LENA-generated adult word counts (left) and transcription-based word counts in the input of blind and sighted children. Violin density represents the distribution of word counts for each group. Grey lines connect values from matched participants. Black dot and whiskers show standard error around the mean. Neither measure differed between groups.
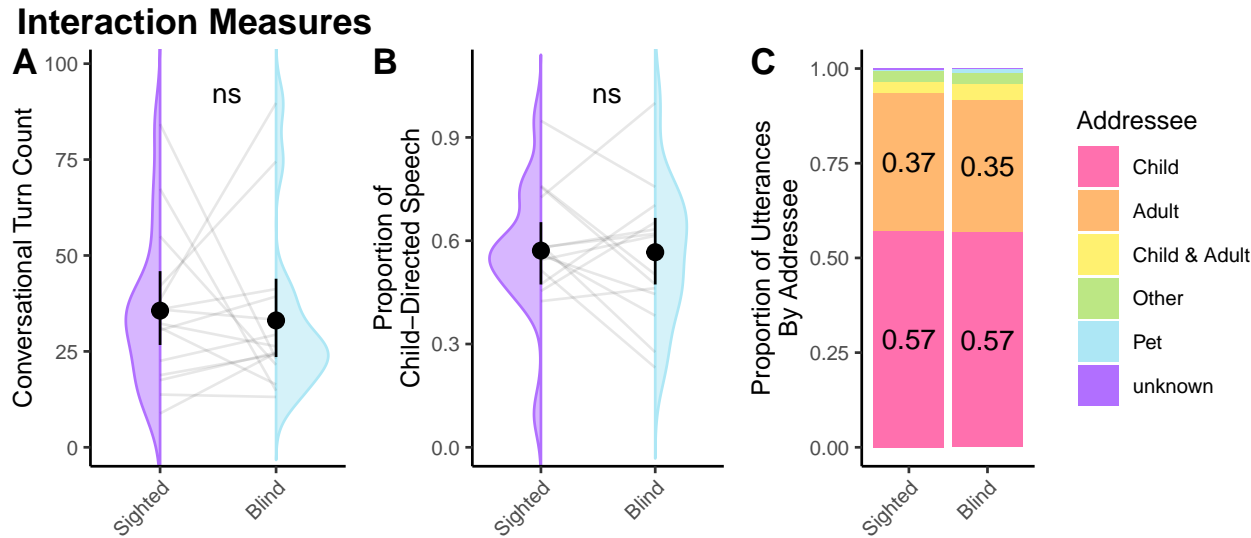
Figure 3. Comparing LENA-generated conversational turn counts (left) and proportion of utterances in child-directed speech (center). Violin density represents the distribution of values for each group. Grey lines connect values from matched participants. Black dot and whiskers show standard error around the mean. The full breakdown by addressee is shown in the rightmost panel. Neither conversational turn count nor proportion of child-directed speech differed between groups.
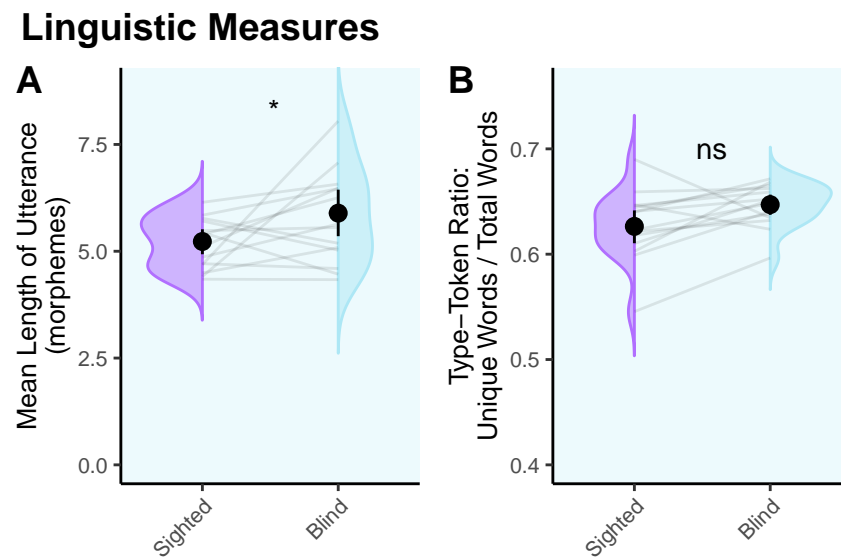
Figure 4. Comparing linguistic features: Mean length of utterance (left) and type-token ratio (right). Violin density represents the distribution of values for each group. Grey lines connect values from matched participants. Black dot and whiskers show standard error around the mean. Utterances in blind children's input were significantly longer, and type-token ratio was significantly higher. Note that the y-axis on the type-token ratio plot has been truncated.
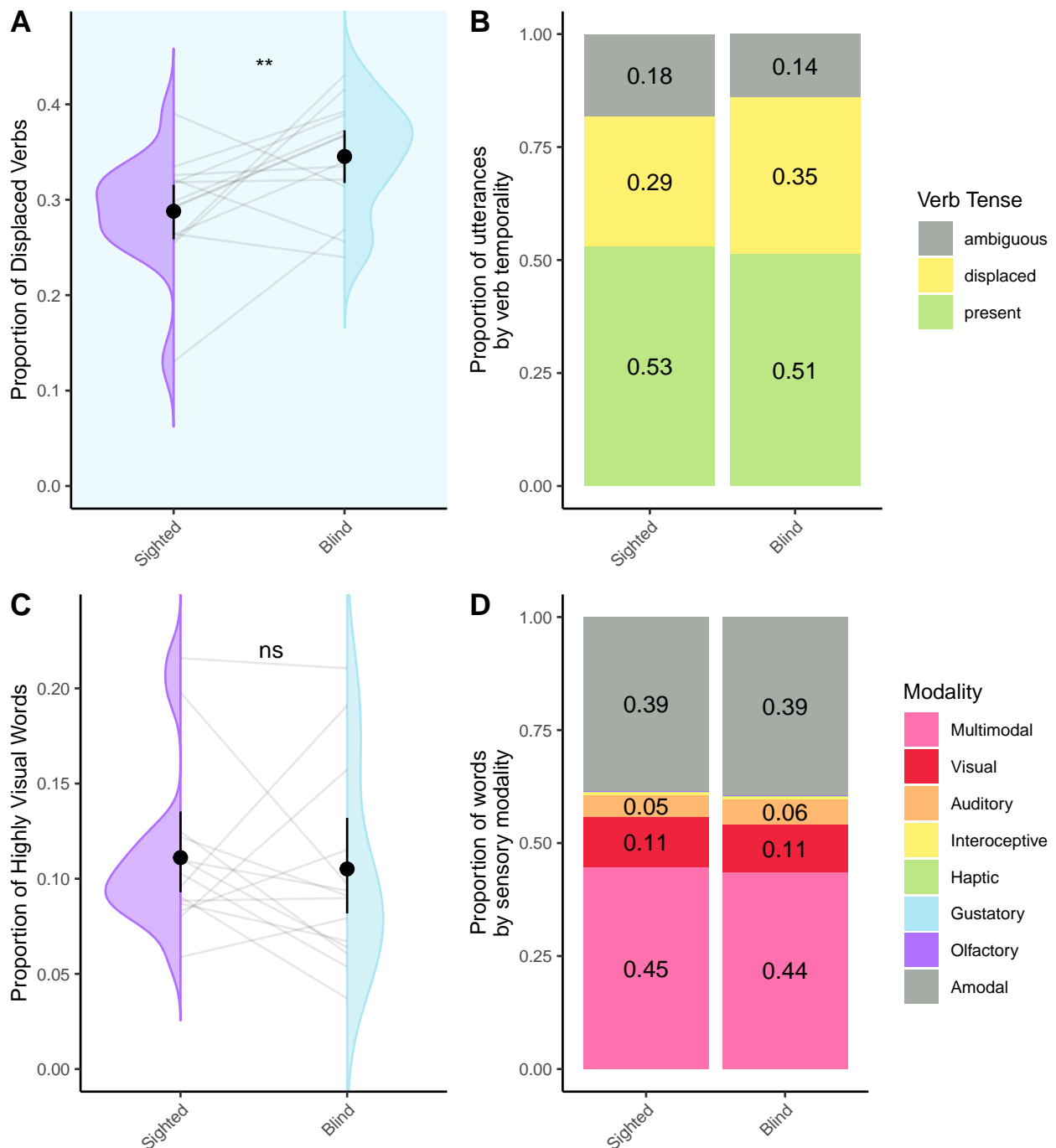
Conceptual Measures

Figure 5. Left col: Comparing proportion of temporally displaced verbs (top) and proportion of highly visual words (bottom). Violin density represents the distribution of values for each group. Grey lines connect values from matched participants. Black dot and whiskers show standard error around the mean. Right col: Full distribution of verb types (top) and sensory modality (bottom) by group, collapsing across participants. Blind children's input contained significantly more temporally displaced verbs. The groups did not differ in the proportion of highly visual words.