# Child language experience in a Tseltal Mayan village

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## Abstract

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*Keywords:* Child-directed speech, Linguistic input, Non-WEIRD, Vocal maturity, Turn taking

Word count: X

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## Introduction

A great deal of work in developmental language science revolves around one central question: What linguistic evidence (i.e., what types and how much) is needed to support first language acquisition? In pursuing this topic, many researchers have fixed their sights on child-directed speech (CDS), showing that it is linguistically distinctive (REFS)[**TASK 00: Add missing references**], interactionally rich (REFS), preferred by infants (REFS), and—perhaps most importantly—facilitates word learning (REFS). One might then conclude that CDS is an essential component for acquiring a first language. Yet ethnographic reports from a number of traditional, non-Western communities suggest that children easily acquire their community's language(s) with little or no CDS (REFS). If so, CDS may not be essential for learning language; just useful for facilitating certain aspects of language development. In this paper we investigate the language environment and early development of 10 Tseltal Mayan children growing up in a community that reportedly uses very little CDS with infants and young children (REFS Brown).

### Child-directed speech

The amount of CDS children hear influences their language development, particularly their vocabulary (REFS). For example, [**TASK 01: Add examples of input-vocab link**]. CDS has also been linked to young children's speed of lexical retrieval (REFS Weisleder; LuCiD) and syntactic development (REFS Huttenlocher). [**TASK 02: Read Huttenlocher and add details here**]. The conclusion drawn from much of this work is that CDS is an ideal register for learning words—especially concrete nouns and verbs—because it is tailored to maximize a child's moment-to-moment interest and understanding (REFS). Indeed, even outside of first-person interaction, infants and young children prefer listening to CDS over adult-directed speech (REFS ManyBabies, etc.), suggesting that CDS is useful in catching, maintaining, and focusing children's attention.

There are, however, a few significant caveats to the body of work relating CDS quantity to language development.

First, while there is overwhelming evidence linking CDS quantity to vocabulary size, links to grammatical development are more scant (REFS: Huttenlocher; Frank et al.). Children must master the systemic underpinnings of their language(s), e.g., the phonology, morphology, and syntax. While the advantage of CDS for referential word learning is clear, it is less obvious how CDS facilitates syntactic learning. [**TASK 03: Add argument from Yurovsky paper + refrences therein**] On the other hand, there is a wealth of evidence that both children and adults' syntactic knowledge is highly lexically specified (REFS), and that, crosslinguistically, children's vocabulary size is one of the most robust predictors of their early syntactic development (REFS). In short, what is good for the lexicon may also be good for syntax. For now, however, the link between CDS and other aspects of grammatical development still needs to be more thoroughly tested.

[**TASK 04: Refine paragraph on burstiness**] Second, most work on CDS quantity uses summary measures which average over the ebb and flow of interaction during sustained co-presence (e.g., proportion CDS). In adult conversation, linguistic behaviors are highly structured: while some occur at fairly regular intervals ("periodic", e.g., discourse connectives), others occur in shorter, more intense bouts separated by long periods of absence ("bursty", e.g., descriptions; REFS Abney 2018 bursts and lulls, see also fusaroli et al. 2014 dialog as interpersonal synergy). Recent work suggests that bursty distributions are typical of child language environments as well, particularly with respect to the distribution of content words. Blasi and colleagues (REFS in prep) find that nouns and verbs are used burstily in child-proximal speech across all six of the languages in their typologically diverse sample. They also find that infrequent words are somewhat more bursty overall, leading them to propose that burstiness may play a key and universal role in helping learners to acquire linguistic units that are otherwise rare. [1] Their findings resonate with those of

[1] In contrast, Drew and Bergelson (REFS in preparation) find that the highest-frequency nouns used in

Schwab and Lew-Williams (2016), who find that two-year-olds learn novel words better from a massed presentation of object labels compared to a distributed presentation (but see contrasting findings from multi-day experiments, e.g., REFS Ambridge et al., 2006; Childers and Tomasello, 2002). Regularities in child language environments are likely to exist at multiple, interlocking timescales (Abney REFS). These temporal characteristics have enormous implications for how attention and memory shape children's language development. By that token, the current link between CDS quantity and linguistic development would be greatly enriched if we accounted for more nuanced distributional properties of CDS (see REFS Mendoza and Fausey (in preparation) for related work on child-proximal music).

Finally, prior work has typically focused on Western (primarily North American) populations, limiting our ability to generalize these effects to children acquiring language worldwide (REFS: WEIRD; Lieven, 1994). While we do gain valuable insight by looking at *within-population* variation (e.g., REFS), we can more effectively find places where our assumptions break down by studying *new* populations. Linguistic anthropologists working in non-Western communities have long reported that caregiver interaction styles vary immensely from place to place, with some caregivers using little or no CDS to young children (REFS Gaskins, 2006). Children in these communities reportedly acquire language with "typical"-looking benchmarks. For example, they start pointing (REFS Liszkowski et al., 2012; but see Salomo & Liszkowski, 2013) and talking (REFS Rogoff et al., 2003?; Brown??) around the same time we would expect for Western middle-class infants. These findings have had little impact on mainstream theories of word learning and language acquisition, partly due to a lack of directly comparable measures (Brown, 2014). If, however, these children indeed acquire language without delay despite little or no CDS, we must reconsider what kind of linguistic evidence is necessary for children to learn language.

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CDS and children's own speech were relatively more bursty than other nouns in comparable American English data. Note, however, that these two studies use different measures of burstiness.

## Language development in non-WEIRD communities

To our knowledge, only a handful of researchers have used methods from developmental psycholinguistics to describe the language environments and linguistic development of children growing up in traditional, non-Western communities. We focus here on *quantitative* language development measures because the key claims about CDS and linguistic development are themselves quantitative in nature. We briefly highlight two recent efforts along these lines, but see Cristia et al. (2017) for a recent review.

Scaff, Cristia, and colleagues (REFS 2017; in preparation) have used a number of methods to estimate how much speech children hear in a Tsimane forager-horticulturalist population in the Bolivian lowlands. Their daylong recordings show that Tsimane children between 0;6 and 6;0 hear ~5 minutes of CDS per hour, with no increase for older children (but see Cristia et al., 2017). For comparison, children from North American homes between ages 0;3 and 3;0 are estimated to hear ~11 minutes of CDS per hour in daylong recordings (REFS: Bergelson, Casillas, et al., see also REFS the newer Tamis-LeMonda paper; maybe give estimates w/ age ranges for each??). In addition to CDS, Tsimane children also hear ~10 minutes of other-directed speech per hour (e.g., talk between adults)—more than the ~7 minutes of adult-directed speech per hour North American children are estimated to hear (REFS Bergelson, Casillas, et al.). This difference may be attributable to the fact that the Tsimane live in extended family clusters of 3–4 households, and so speakers are typically in close proximity to 5–8 other people (REFS Cristia et al., 2017).

Laura Shneidman and colleagues (REFS; 2010; 2012) analyzed speech from 1-hour at-home video recordings of children between ages 1;0 and 3;0 in two communities: Yucatec Mayan (Southern Mexico) and North American (in a major US city). Their analyses yielded four main findings: compared to the American children, (a) the Yucatec children heard many fewer utterances per hour, (b) a much smaller proportion of the utterances they heard were *child-directed*, (c) the proportion of utterances that were child-directed increased dramatically with age, matching U.S. children's by 3;0 months, and (d) most of the added

CDS came from other children (e.g., older siblings and cousins). They also demonstrated that the lexical diversity of the CDS they hear at 24 months—particularly from adult speakers—predicted children's vocabulary knowledge at 35 months.

These groundbreaking studies establish a number of important findings: First, children in each of these communities appear able to acquire their languages with relatively little CDS. Second, CDS may become more frequent as children get older, though this may be largely due to speech from other children. Finally, despite these differences, CDS from adults may still be the most robust predictor of vocabulary growth.

## The current study

We examine the early language experience of 10 Tseltal Mayan children under age 3;0. Prior ethnographic work suggests that Tseltal caregivers do not frequently speak directly to their children until the children themselves begin speaking (REFS: Brown??). Nonetheless, Tseltal children develop language with no apparent delays. Tseltal Mayan language and culture has much in common with the Yucatec Mayan communities Shneidman has worked with (REFS: 2010 + add other stuff that's not nec lg), which allows us to compare differences in child language environments between the two sites more directly than before.\footnote{For a review of comparative work in developmental linguistic anthropology, particularly on Mayan cultures, see Pye (2017).) We provide more details on this community and dataset in the Methods section.

Similar to previous work by Shneidman, Scaff, Cristia, and colleages, we estimated how much speech children overheard, how much was directed to them, and how those quantities changed with age. To this foundation we added new sampling techniques for investigating variability in children's speech environments within daylong recordings. We also analyzed children's early vocal productions, examining both the overall developmental trajectory of their vocal maturity and how their vocalizations are influenced by CDS.

Based on prior work, we predicted that Tseltal Mayan children hear little CDS, that

the amount of CDS they hear increases with age, that most CDS comes from other children, and that, despite this, Tseltal Mayan children would hit early speech production benchmarks on par with Western children. We additionally predicted that children's language environments would be bursty—that brief, high-intensity interactions would be sparsely distributed throughout the day, accounting for the majority of children's daily CDS—and that children's responsiveness and vocal maturity would be maximized during these moments of high-intensity interaction.

## Methods

### Community

The children in our dataset (REFS: Casillas HomeBank) come from a small-scale, subsistence farming community in the highlands of Chiapas in Southern Mexico. The vast majority of children grow up speaking Tseltal monolingually at home. Primary school is conducted in Tseltal, but secondary and further education is primarily conducted in Spanish. Nuclear families are often large (5+ children) and live in patrilineal clusters. Nearly all families grow staple crops such as corn and beans, but also bananas, chilies, squash, coffee, and more. Household and farming work is divided among men, women, and older children. Women do much of the daily cleaning and food preparation, but also frequently work in the garden, haul water and firewood, and do other physical labor. A few community members—both men and women—earn incomes as teachers and shopkeepers but are still expected to regularly contribute to their family's household work.

More than forty years of ethnographic work by the second author has told us that Tseltal children's language environments are non-child-centered and non-object-centered (REFS). During their waking hours, Tseltal infants are typically tied to their mother's back while she goes about her work for the day. Infants receive very little direct speech until they themselves begin to initiate interactions, usually as they approach their first birthdays. Even then, interactional exchanges are often brief or non-verbal (e.g., object exchange routines)

and take place within a multi-participant context (Brown 2011; 2014). Rarely is attention given to words and their meanings, even when objects are central to the activity. Instead, interactions tend to focus on appropriate actions and responses, and young children are socialized to attend to the interactions taking place around them (REFS see also Rogoff and de Leon).

Young children are often cared for by other family members, especially older siblings. Even when not on their mother's back, infants are rarely put on the ground, so they can't usually pick up the objects around them until they are old enough to walk. Toys are scarce and books are vanishingly rare, so the objects children do get their hands on tend to be natural or household objects (e.g., rocks, sticks, spoons, baskets, etc.). By age five, most children are competent speakers who daily engage in chores and caregiving of their younger siblings. The Tseltal approach to caregiving is similar to that described for other Mayan communities (e.g., REFS Rogoff, Gaskins, de Leon, Shneidman).

## Corpus

The current data come from the Casillas HomeBank Corpus (REFS HomeBank), which includes daylong recordings and other developmental language data from 55+ children under 4;0 in two indigenous, non-WEIRD communities: the Tseltal Mayan community described here and a Papua New Guinean community described elsewhere (REFS).

*[TASK 06: Check these demographic data again]* The Tseltal data, which were primarily collected in 2015, include recordings from 55 children born to 43 mothers. The families in our dataset typically only had 2–3 children (median = 2; range = 1–9), due to the fact that the participating families represent a fairly young subsample of the community (mothers: mean = 26.9 years; median = 25.9; range = 16.6–43.8 and fathers: mean = 30.5; median = 27.6; range = 17.7—52.9). On average, mothers were 20.1 years old when they had their first child (median = 19; range = 12–27), with a following inter-child interval of

3.04 years (median = 2.8; range = 1–8.5).[2]. As a result, 26% of the participating families had two children under 4;0.

Extended households, defined in our dataset as the group sharing a kitchen or other primary living space, ranged between between 3 and 15 people (mean = NN; median = NN). Although 30.9% of the target children are first-born, they were rarely the only child in their extended household. Caregiver education is one (imperfect) measure of contact with Western culture. Most mothers had finished primary school, with many also having completed secondary school (range = no schooling–university). Most fathers had finished secondary school, with many having also completed preparatory school (range = no schooling–university). Owing in large part to the patrilineal allocation of land (i.e., father to son), 93% of the fathers grew up in the village where the recordings took place, while only 53% of the mothers did.

**Recordings.** Methods for estimating the quantity of speech that children hear have advanced significantly in the past two decades, with long-format (4+ hour) at-home audio recordings quickly becoming the new standard (e.g., with the LENA® system; REFS). These recordings capture a wider range of the linguistic patterns children hear as they participate in different activities with different speakers over the course of their day. In longer, more naturalistic recordings, caregivers also tend to use less CDS (REFS Tamis-LeMonda). The result is greater confidence that the estimated CDS characteristics are representative of what the child typically hears at home.

We used a novel combination of a lightweight stereo audio recorder (Olympus® WS-832) and wearable photo camera (Narrative Clip 1®) fitted with a fish-eye lens, to track children's movements and interactions over the course of a 9–11-hour period in which the experimenter was not present. Each recording was made during a single day at home in which the recorder and/or camera was attached to the child. Ambulatory children wore both devices on an elastic vest. Non-ambulatory children wore the recorder in a onesie while their

[2]These estimates do not include miscarriages and/or children who passed away.

primary caregiver wore the camera on an elastic vest *Figure 1 [TASK 07: Make figure].* The camera was set to take photos at 30-second intervals and was synchronized to the audio in post-processing to create video of the child's daylong recording.[3]

## Data selection and annotation

We annotated video clips from 10 of the 55 children's recordings. We chose these 10 recordings to maximize variance in three demographic variables: child age (0–3;0), child sex, and maternal education. The sample is summarized in *Table 1 [TASK 09: Make table].* We then selected one hour's worth of non-overlapping clips from each recording in the following order: nine randomly selected 5-minute clips, five 1-minute clips manually selected as the top "turn-taking" minutes of the recording, five 1-minute clips manually selected as the top "vocal activity" minutes of the recording, and one, manually selected 5-minute extension of the best 1-minute sample *FIGURE ?? [TASK 10: Add figure of recording times with samples highlighted for the 10 recs].* We created these different subsamples of each day to measure properties of (a) children's *average* language environments (random samples) and (b) their *most input-dense* language environments (turn-taking samples). The third sample (high-activity) gave us insight into children's productive speech abilities.

The turn-taking and high-activity clips were chosen by two trained annotators (the first author and a student assistant) who listened to each recording in its entirety at 1–2x speed while actively taking notes about potentially useful clips. Afterwards, the first author reviewed the list of candidate clips, listened again to each one (at 1x speed, multiple repetitions), and chose the best five 1-minute samples for each of the two types of activity. Good turn-taking activity was defined as at closely timed sequences of contingent vocalization between the target child and at least one other person (i.e., frequent vocalization exchanges). The "best" turn-taking clips were chosen because they had the most and most clear turn-switching activity between the target child and the other speaker(s).

[3]Documentation for recording set-up and scripts for post-processing are available at *[TASK 08: Link to relevant docs]*

Good vocal activity clips were defined as clips in which the target child produced the most and most diverse spontaneous (i.e., not imitative) vocalizations. The "best" vocal activity clips were chosen for representing the most linguistically mature and/or diverse vocalizations made by the child over the day. All else being equal, candidate clips were prioritized when they contained less background noise or featured speakers and speech that were not otherwise frequently represented (e.g., CDS from older males). The best turn-taking clips and vocal activity clips often overlapped; turn-taking clips were selected from the list of candidates first, and then vocal-activity clips were chosen from the remainder.

Each video clip was transcribed and annotated in ELAN (REFS) using the ACLEW Annotation Scheme (REFS) by the first author and a native speaker of Tseltal who lives in the community and knows most of the recorded families personally. At the time of writing, NN% *[TASK XX: Fill in before submitting]* of the clips have been reviewed by a second, highly literate native Tseltal speaker with extensive training in ELAN. The annotations include the transcription of (nearly) all hearable utterances in Tseltal, a loose translation of each utterance into Spanish, vocal maturity measures of each target child utterance (non-linguistic vocalizations/non-canonical babbling/non-word canonical babbling/single words/multiple words), and addressee annotations for all non-target-child utterances (target-child-directed/other-child-directed/adult-directed/adult-and-child-directed/animal-directed/other-speaker-type-directed).[4]

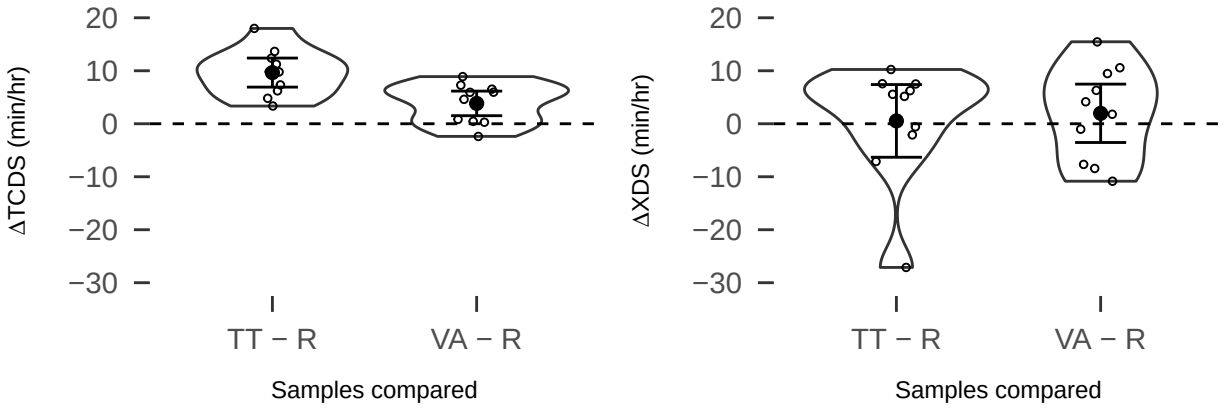
## Data analysis

We reformatted each ELAN file into tab-separated values in order to read the annotations into R version 3.5.0 (2018-04-23) for analysis. We made plots with the ggplot2 package and ran all analyses with the lme4 and betareg packages *[TASK 12: Fix references to packages and their citations]*. We then calculated a number of summary variables to characterize children's language environments and linguistic development including: the

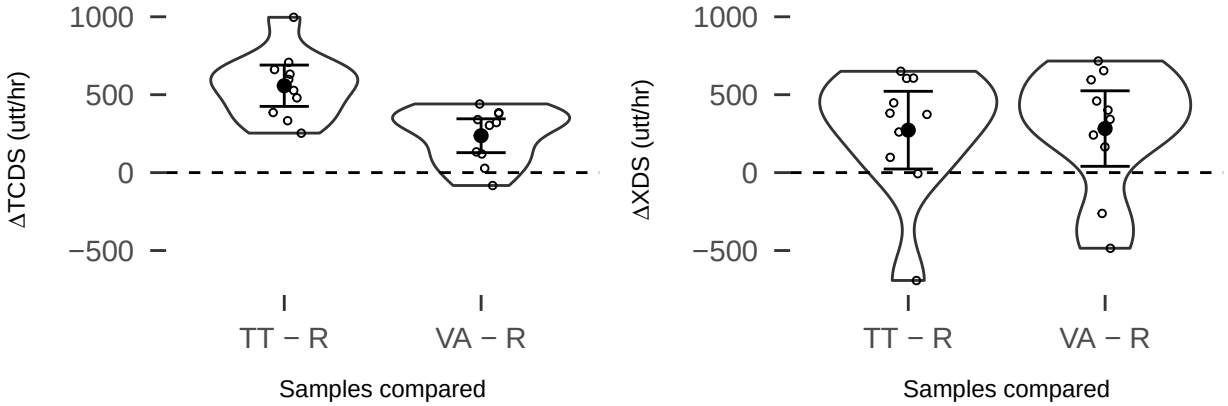
[4]Full documentation, including training materials, for the ACLEW Annotation Scheme can be found at *[TASK 11: Add OSF link]*.

quantity of all overheard speech and all speech directed to the target child ("TCDS") in both minutes per hour and utterances per hour, the proportion of speech in CDS and coming from adult vs. child speakers, the number of target child-to-other and other-to-target child turn transitions per hour, the minutes of vocalization produced by target children per hour, and the average maturity of children's vocalizations. Using language environment measures from the turn-taking sample, we then also estimated the number of intensive interaction minutes each child experienced over the day.

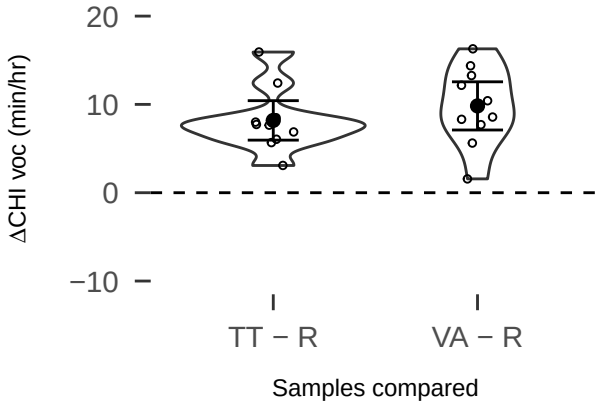
## Results

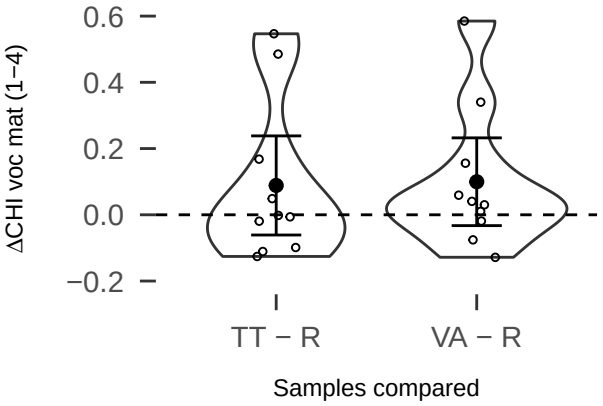

ΔTCDS (min/hr)
20
10
0
−10
−20
−30
TT − R
VA − R
Samples compared

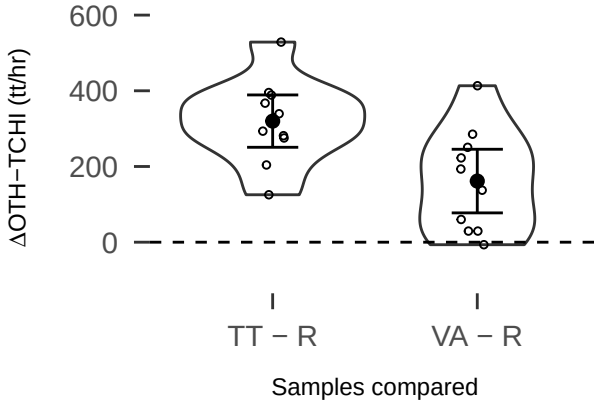

ΔXDS (min/hr)
20
10
0
−10
−20
−30
TT − R
VA − R
Samples compared

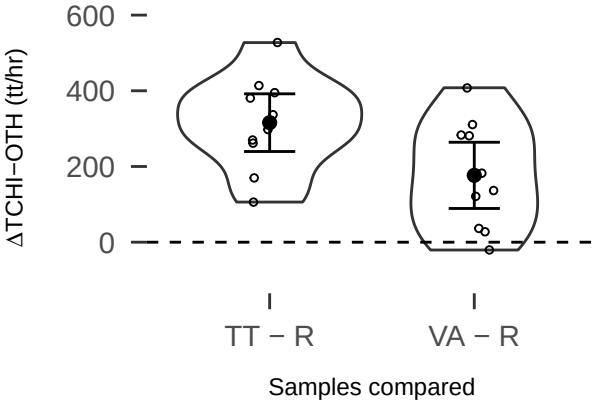

ΔTCDS (utt/hr)
1000
500
0
−500
TT − R
VA − R
Samples compared


ΔXDS (utt/hr)
1000
500
0
−500
TT − R
VA − R
Samples compared


ΔCHI voc (min/hr)
20
10
0
−10
TT − R
VA − R
Samples compared


ΔCHI voc mat (1−4)
0.6
0.4
0.2
0.0
−0.2
TT − R
VA − R
Samples compared


ΔOTH−TCHI (tt/hr)
600
400
200
0
TT − R
VA − R
Samples compared


ΔTCHI−OTH (tt/hr)
600
400
200
0
TT − R
VA − R
Samples compared

278 # Discussion

279 ## Future directions

280 ## Conclusion

281 # Acknowledgements

282 ## References

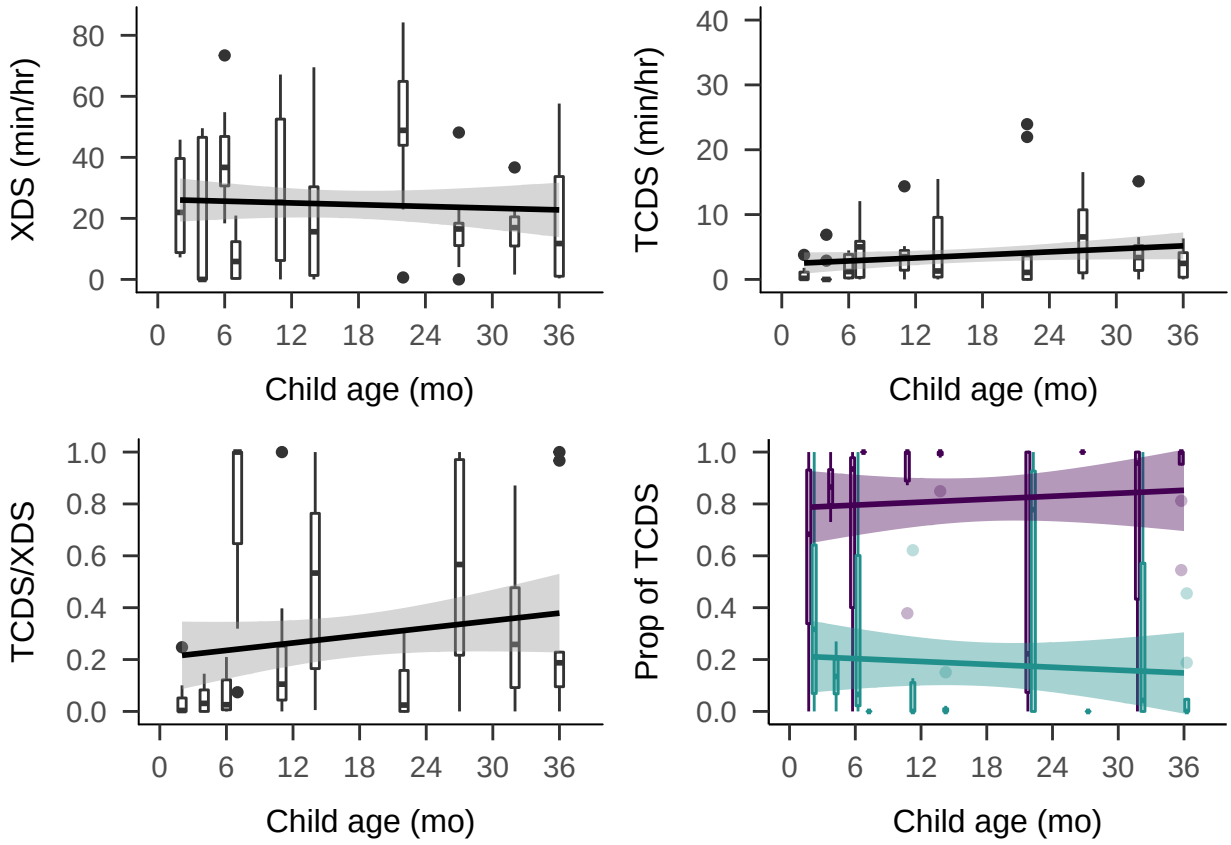

XDS (min/hr)
0
20
40
60
80
0
6
12
18
24
30
36
Child age (mo)
TCDS (min/hr)
0
10
20
30
40
0
6
12
18
24
30
36
Child age (mo)
TCDS/XDS
0.0
0.2
0.4
0.6
0.8
1.0
0
6
12
18
24
30
36
Child age (mo)
Prop of TCDS
0.0
0.2
0.4
0.6
0.8
1.0
0
6
12
18
24
30
36
Child age (mo)

*Figure 1*

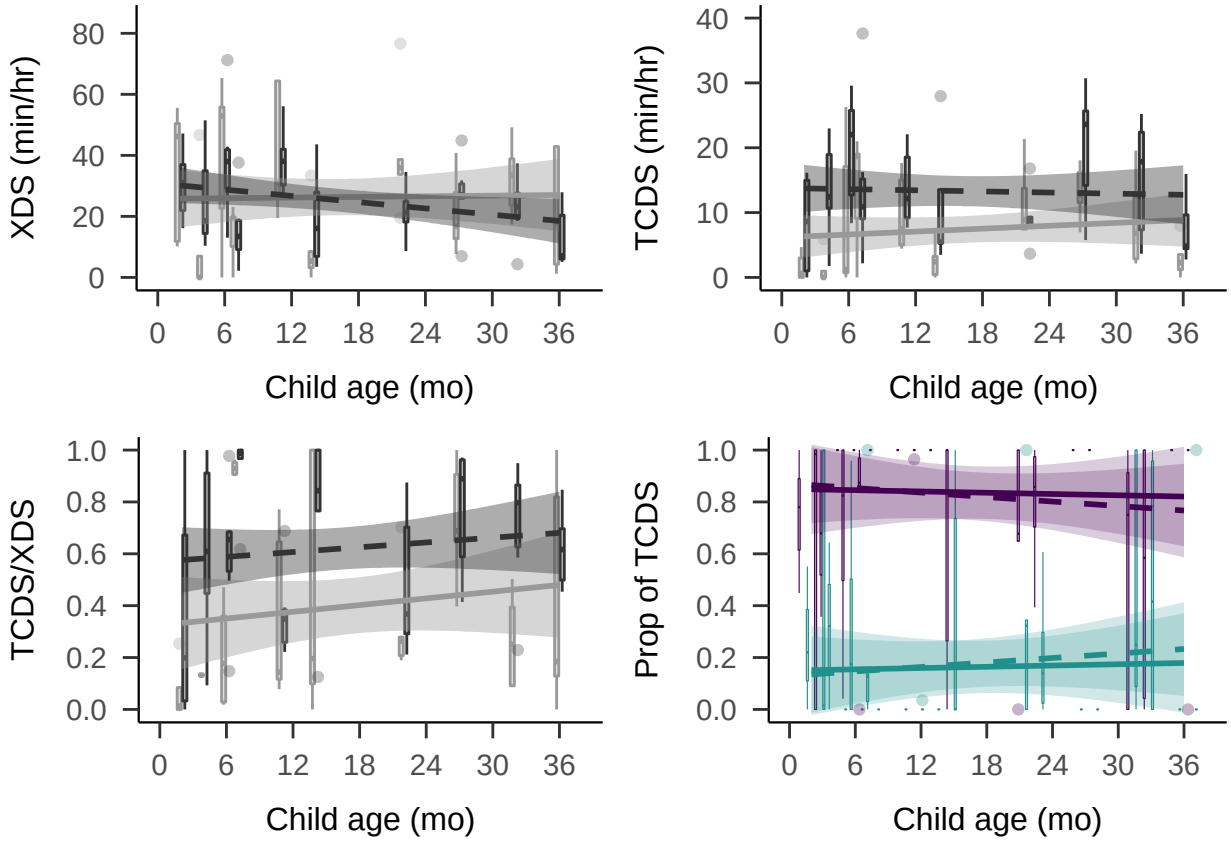

XDS (min/hr)
TCDS (min/hr)
TCDS/XDS
Prop of TCDS
Child age (mo)
0
6
12
18
24
30
36

*Figure 2*

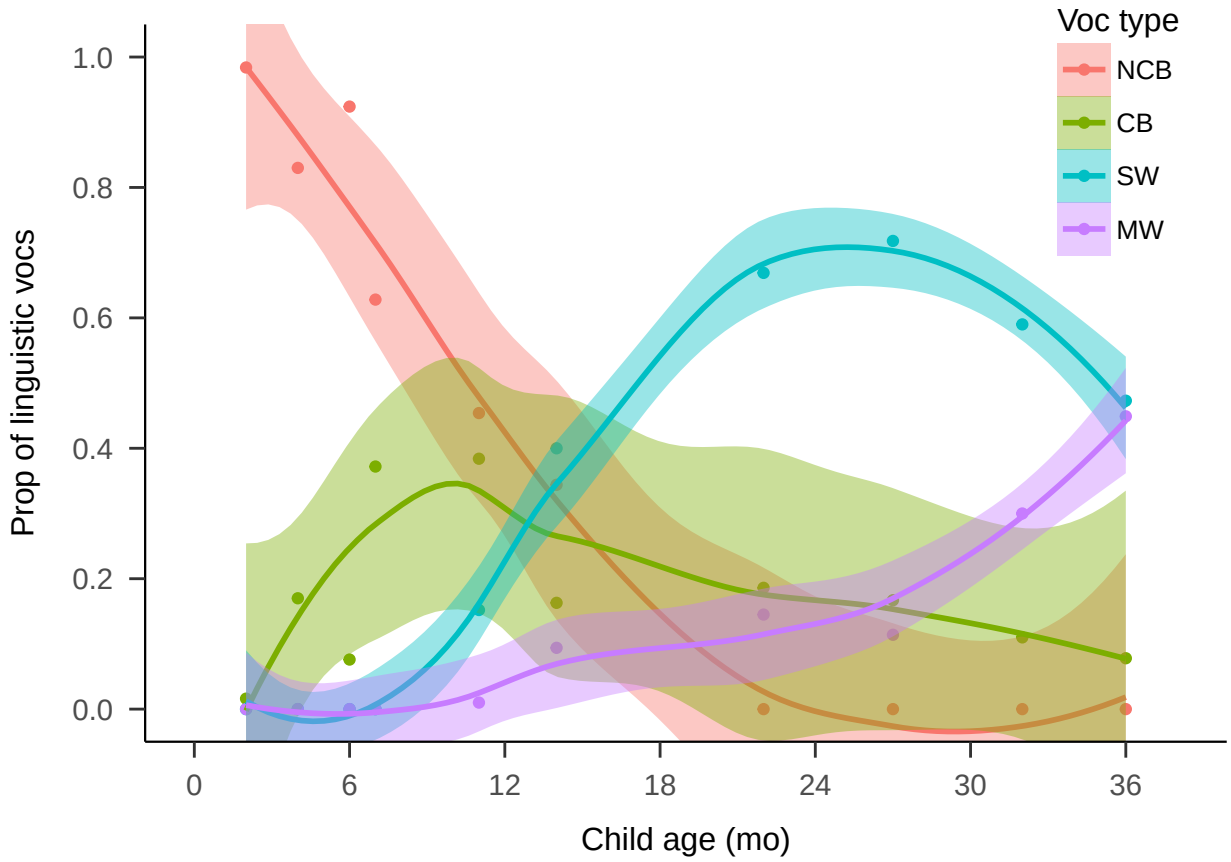

Voc type
NCB
CB
SW
MW
Prop of linguistic vocs
1.0
0.8
0.6
0.4
0.2
0.0
0
6
12
18
24
30
36
Child age (mo)

*Figure 3*