1    The Development of English Negative Constructions and Communicative Functions in Early

2                                            Child Language

3                                    Zoey Liu[1] & Masoud Jasbi[2]

4                                        [1] Boston College

5                                    [2] Uinversity of California, Davis

6                                            Author Note

7        Zoey Liu, Department of Computer Science, Boston College

8        Masound Jasbi, Department of Linguistics, University of California, Davis

9        Correspondence concerning this article should be addressed to Zoey Liu, . E-mail:

10   zoey.liu@bc.edu

Abstract

How does the abstract concept of linguistic negation develop in early child language? Prior research has suggested that the concept of negation develops from more concrete communicative functions such as rejection, prohibition, or non-existence, with each function emerging in different stages. The evidence for the emergence of these functions in separate stages is mixed, however, leaving the possibility that negation is an abstract concept that can serve multiple specific functions since the beginning, and that the development of the different functions start more or less simutanouesly depending on early communicative environment. Leveraging automatic annotations of large-scale child speech corpora in English, we examine the production trajectores of seven negative constructions that tend to convey communicative functions previously discussed in the literature. The results demonstrate the emergence and gradual increase of these constructions in child speech within the age range of 18-36 months at both sentence and discourse level. Production mostly becomes stable, regular, and comparable to parents' levels after this age range. These findings suggest that different communicative functions of negation share comparable production trajectory and do not clearly follow a fixed developmental order. Alternatively, it is possible that these functions emerge so early and quickly that even though they might develop in different stages, it is not detectable from the available corpus data.

*Keywords:* negation; syntactic construction; communicative function; data-driven; child language development.

Word count: X

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## Introduction

Negation is a basic human concept and foundational to many areas of human thought including logic and mathematics (Haspelmath, 1997; Jespersen, 1917). An important feature of linguistic negation is that it has an abstract meaning and serves different communicative functions in different contexts. In English, for example, a coffee shop can use *not* to divide the menu into "coffee" and "not coffee" sections, with "not coffee" bringing together diverse items such as tea and hot chocolate. The coffee shop can use *no* in a sign like "no mask, no entry" to regulate customer behavior, and an employee could say "I don't like Mondays" to express their dislike for coming back to work on Mondays. Despite its abstract meaning, a word like *no* is among the early words produced by children. Therefore, a fundamental question in cognitive development and language acquisition is how negation emerges and develops in the human mind. Is early development of negation in child language specific to a few communicative functions? Or does negation emerge as an abstract and multi-functional concept from the beginning?

Previous literature has proposed that abstract negation develops from less abstract communicative functions in a fixed order (Bloom, 1970; Choi, 1988; McNeill & McNeill, 1968; Pea, 1978). In other words, different functions of negation have been argued to have separate *stages* of acquisition. For instance, Darwin (1872) hypothesized that headshake as a sign for negation (in some culture) develops from infants' habit to refuse or reject food from parents by withdrawing their heads. Similarly, Pea (1978) proposed that at first, children use *no* to convey "rejection." In a second stage, they conceptualize and express non-existence of objects (e.g., "no water [in the cup]"), and finally in the third stage, negation reaches an abstract status that can deny truth of statements (e.g., "that is not a cow"). For Pea (1978),

this order reflected a natural progression in the conceptual space: from the more primitive domain of internal desires to the more complex domain of external existence, and finally abstract truth.

As we will discuss in the next section, as fruitful as prior work is, their theoretical and empirical landscape is not always so clean. Therefore while negation does serve multiple communicative functions, there has been no consensus reached regarding two respects:

(1) Does negation develop from different communicative functions in fixed ordered stages?

(2) If so, what is the developmental order of these functions?

In this study, we take up the aforementioned two questions with a data-driven approach. Leveraging child-speech corpora in English, we investigate the developmental patterns of seven communicative functions of negation that have gained much attention in prior research. On the basis that children's early linguistic production reflects developmental stages, our results suggest that negation starts as an abstract concept that can be used to perform multiple communicative functions from the beginning, depending on the demands of early linguistic interactions. The overall developmental trajectory of each function is similar to each other in terms of when the production of the function emerges, the age range where substantial development is observed, the estimated maximum capacity of production, and the point at which production starts to become stable. These findings do not seem to provide clear evidence for what has been widely speculated in the literature, which posits that the developmental paths of separate communicative functions of negation are noticeably different. In what follows, we review previous studies on children's production of negation, then move on to details of our own experiments.

<sub>79</sub> **Previous Studies**

<sub>80</sub>    Darwin (1872, Chapter 11) explained the emergence of linguistic negation using the

<sub>81</sub> function it plays in early communication. He hypothesized that nodding and shaking are the

<sub>82</sub> earliest expressions of affirmation and negation respectively and argued:

<sub>83</sub>    With infants, the first act of denial consists in refusing food; and I repeatedly noticed

<sub>84</sub> with my own infants, that they did so by withdrawing their heads laterally from the breast,

<sub>85</sub> or from anything offered them in a spoon . . . [moreover] . . . when the voice is exerted with

<sub>86</sub> closed teeth or lips, it produces the sound of the letter *n* or *m*. Hence we may account for

<sub>87</sub> the use of the particle *ne* to signify negation, . . .

<sub>88</sub>    In later research, this communicative function of negation was referred to as "rejection"

<sub>89</sub> or "refusal" (Bloom, 1970; Choi, 1988; Pea, 1978).

<sub>90</sub>    Unlike Darwin, McNeill and McNeill (1968)'s developmental account did not start with

<sub>91</sub> rejection, but rather with expressing external states (non-existence of objects). They studied

<sub>92</sub> the development of three Japanese negative morphemes (*nai, iya, iiya*) in the speech of a

<sub>93</sub> 27-month-old Japanese speaking girl called Izanami. According to McNeill and McNeill

<sub>94</sub> (1968), in Japanese, *nai* expresses falsity of statements (e.g., "*no* [that's *not* an apple]), *iya*

<sub>95</sub> expresses desires (e.g.,"*no* [I don't want an apple]"), and *iiya* expresses contrast (e.g., *no* [I

<sub>96</sub> didn't have an apple. I had a pear]). Therefore their appearance in the speech of a child

<sub>97</sub> reflects the developmental stages for the respective communicative functions. They reported

<sub>98</sub> that in the first stage, Izanami used a simple negation like *nai* to express non-existence of

<sub>99</sub> events and objects. They also mentioned the early use of *shira-nai* ("I don't know") but did

<sub>100</sub> not incorporate it into their developmental account. In the second stage, Izanami used

<sub>101</sub> negation to mark incorrectness of statements, e.g., saying"false". Such use of negation was

<sub>102</sub> labeled as"denials" in later research. In stage three, negation was also used to express

<sub>103</sub> disapproval or rejection - like saying "I don't want that." In the fourth stage, Izanami used

104 negation to express contrasts - as if to say "not this but something else." According to

105 McNeill and McNeill (1968), these stages took about five months.

106      Bloom (1970) considered three communicative functions for early negation:

107 non-existence, rejection, and denial. She studied three children, two from 19 months and

108 another from 21 months of age. She argued that in all three children, negation was produced

109 in the following order: non-existence, rejection, and denial. Table 1 provides a few examples

110 for each category. Many of these examples do not immediately stand out as instances of

111 their category. This is partly because many early examples in child production are fairly

112 short with underspecified syntactic structures, leading their interpretations to be heavily

113 reliant on the context. It is therefore hard to assess the intention behind the use of negation

114 in such cases.

Table 1

*Examples of non-existence, rejection, and denial negation in the speech of Eric, Kathryn, and Gia from Bloom (1970).*

| Non-existence | Rejection | Denial |
|---|---|---|
| **no** *more choochoo train* | **no** *train* | **no** *Daddy hungry* |
| **no** *more noise* | **no** *want this* | **no** *more birdie* |
| **no** *children* | **no** *bear book* | **no** *ready* |
| **no** *it won't fit* | **no** *go outside* | **no** *tire* |
| *Kathryn* **no** *like celery* | **no** *dirty soap* | **no** *dirty* |

115      Pea (1978) studied six children between the ages of 8-24 months. Children were

116 recorded in their homes for about 90 minutes every month. All utterances that convey a

117 negative meaning (e.g., containing *no*, *not*, *all gone*, *gone*, *away*, *stop*) and gestures (e.g.,

118 headshakes and headnods) were annotated and analyzed. Pea (1978) reported that children

119 first started by using negation to express internal states (rejection), then external states

120 (non-existence), and finally they used negation to connect language and the external world,

121 (e.g., truth-functional negation or denials). This was in direct contradiction to McNeill and

122 McNeill (1968) who proposed that children start with expressing external states before

123 internal states.

124      de Villiers and de Villiers (1979) examined the communicative functions of negation in

125 the speech of Adam (27-31 months), Eve (18-22 months), and their own child Nicholas (23-29

126 months). The first two children were recorded for an hour every two or three weeks (Brown,

127 1973). They annotated children's examples of negation for six communicative functions:

128 non-existence, disappearance, non-occurrence, cessation, rejection, and denial. Disappearance

129 referred to cases where an object became hidden and cessation referred to the use of negation

130 when a movement or action stopped (e.g., "no walk" when a toy stopped walking). They

131 found rejections and denials to be the most frequent (and most reliable-to-annotate)

132 functions of negation, both present in the earliest samples of children's speech.

133      Choi (1988) looked at the speech of 11 children (2 English, 4 Korean and 5 French

134 speaking) between 19 to 40 months of age. She reported 9 communicative functions for

135 children's negation shown in Table 2. She matched communicative functions with linguistic

136 constructions that commonly convey them and proposed that these constructions and

137 functions developed in three phases. First, children used "*no*" alone to express the four

138 functions of non-existence, prohibition, rejection, and failure. In the second phase, *no* was

139 used to express denial, inability, and epistemic negation. New constructions such as

140 "not+Noun Phrase" (e.g., "not a bee"), *can't* (e.g. "I can't put back"), and "I don't know"

141 also emerged to express these functions. New constructions were also used to distinguish the

142 functions in the previous phase such as rejection (e.g. "I don't want to"). In the third phase,

143 normative negation and inferential negation emerged in children's speech with modal

144 auxiliaries like *can't*. Negative forms for prohibition also appeared with the structure

145 "don't+Verb."

Table 2

*Examples of communicative functions and their forms in Choi (1988).*

| Function | Definition | Constructions | Example |
|---|---|---|---|
| Non-existence | expressing absence of entities | *no*+V | "*no more*" (after emptying a bag) |
| Failure | expressing absence of an event | *it won't* | "*not work*" (puzzle piece not fitting) |
| Prohibition | negating actions of others | *don't* + V | |
| Rejection | negating the child's own actions | *I don't want (to)* | |
| Denial | negating others' propositions | AUX + *not* | "*no that's a pony*" (in response to "Is this a car?") |
| Inability | expressing physical inability | | "*can't!*" (taking two lego pieces apart) |
| Epistemic | lack of knowledge | *I don't know* | "*I don't know*" (in response to "what color is this?") |
| Normative | expressing expected norms | *(you) can't* | "*Him can't go on a boat*" |
| Inferential | child's inference about the listener | AUX + *not* | "*I not broken this*" (seeing a broken crayon) |

<sub>146</sub> Cameron-Faulkner, Lieven, and Theakston (2007) recorded an English speaking child

<sub>147</sub> for an hour five times a week between the ages of 27 to 39 months. They classified his

negative utterances into seven communicative functions by using categories from Choi (1988) and leaving out normative and inferential negation. They found examples of all seven functions in Brian's early speech. Starting at 27 months, single-word discourse-level *no* was used to convey most functions but gradually other forms using *not, don't, can't,* or *won't* emerged and replaced *no* in usage. For instance with inability and prohibition, Brian mostly used *no* and *not* at 27 months but switched to *can't* to express inability, and *don't* to express prohibition at 39 months. Cameron-Faulkner, Lieven, and Theakston (2007) argued that at 27 months, Brian had a broad conceptualization of negation and likely represented it as a "unitary category in conceptual space."

In a recent study, Nordmeyer and Frank (2018) looked at twice-a-month recordings of five children between the 12-36 months of age (1-3 years) in the Providence corpus (Demuth, Culbertson, & Alter, 2006) and classified children's negative utterances into seven functional categories: disappearance, prohibition, self-prohibition, refusal (rejection), failure, denial, and unfulfilled expectations. Self-prohibition referred to cases where children addressed a prohibition to themselves (e.g. saying *no* to themselves when reaching for a forbidden object) and unfulfilled expectations referred to instances that expressed surprise when an object was not in an expected place, similar to some cases of non-existence in previous research. They found that refusal (rejections) and denial were the most common functions in children's production and that children varied with respect to which function was produced first. In line with de Villiers and de Villiers (1979), they concluded that the developmental trajectory of different communicative functions of negation may not be as consistent across individuals as some previous research had suggested.

Table 3

*Summary of previous studies on the development of negation's communicative functions; "variable" indicates the developmental order of different functions claimed by the study is not fixed.*

| Study | Number of Children | Age Range (Months) | Proposed Functional Stages |
| --- | --- | --- | --- |
| McNeill and McNeill (1968) | 1 | 27-32 | non-existence > denial (non-contrastive) > rejection > denial (contrastive) |
| Bloom (1970) | 3 | 19-28 | non-existence > rejection > denial |
| Pea (1978) | 6 | 8-24 | rejection > non-existence > denial |
| de Villiers and de Villiers (1979) | 3 | 18-31 | rejection, denial (variable) |
| Choi (1988) | 11 | 19-40 | non-existence, prohibition, rejection, failure > denial, inability, epistemic > normative, inferential |
| Cameron-Faulkner, Lieven, and Theakston (2007) | 1 | 27-39 | non-existence, failure, prohibition, rejection, denial, inability, epistemic |
| Nordmeyer and Frank (2018) | 5 | 12-36 | denial, rejection, prohibition, failure, disappearance (variable) |

170          Table 3 provides a summary of previous research on the communicative functions of

171 negation in children's speech. As the summary shows, there is currently no consensus on

172 which functional categories should be included or in which order they are produced. Here we

are going to discuss three possible reasons for this lack of consensus. First, de Villiers and de Villiers (1979) and Nordmeyer and Frank (2018) have emphasized that there is considerable variability among children and their parents in their use of negation. Given that previous studies have typically considered only a few children (3-4 on average), they could have reached conclusions that are true of their sample but not of the population of (native) English-speaking children.

Second, previous studies have used monthly or fortnightly recordings of children's speech for about 60-90 minutes per recording session. Given that children produce many hours of speech daily, such sparse sampling might have created accidental gaps for certain communicative functions and consequently made it as if functions appear in ordered stages. The only study with relatively dense recording is Cameron-Faulkner, Lieven, and Theakston (2007) which reports the presence of all communicative functions in the child's speech from early on. However, the recordings for their study start at a later age (27 months) than many other studies.

Third, prior research shows that defining and detecting the communicative functions of negation is not a trivial task. Different studies have sometimes used different basic categories and different definitions or criteria for classifying negative utterances. Therefore, what counts as an instance of rejection or non-existence may vary among studies and contribute to the reported variability. Most importantly, annotations focus on many utterances with underspecified syntactic structures such as "no car" or "no more," which are highly ambiguous and can count as an instance of different communicative functions. Does "no car" mean "there is no car here" (non-existence) or "I don't want a toy car" (rejection)? Researchers often have to rely on the context but the context is not fully represented in many child language corpora used for annotations. More importantly, this approach is not scalable to larger numbers of children and bigger corpora since manual annotations take considerable amount of time, energy, and training. In the next section, we discuss how the

current study addresses these three issues.

## Current Study

We build on previous research and address the methodological issues discussed in the previous section in two ways. First, in this study we use large corpora of parent-child interactions, aggregating speech samples from 693 children between the ages of 1-6 years (12-72 months). If the lack of consensus in previous research was mainly due to the small number of children, increasing this number should address the issue. Aggregating speech samples across children would also provide denser samples at each time interval and reduce the possibility of accidental gaps in age intervals. The reasoning behind this approach is that despite individual variation, if there are major developmental stages, they should be detectable in large aggregate corpora of child speech.

Second, in this study we shift the focus from detecting and classifying negative communicative functions such as rejection to detecting and classifying negative constructions that typically communicate them. This approach is similar in spirit to that of Choi (1988) who manually annotated for both communicative functions and their common linguistic constructions (Table 3). Here by negative constructions, we refer to syntactic constructions modified by any one of the three negative morphemes in English: *no*, *not*, *n't*. Table 4 summarizes the constructions and communicative functions used in this study. This approach has several advantages. To begin with, negative constructions are more concrete and thus easier to define. For example, utterances that combine negation with the main verb *want* (e.g., "I don't want that") constitute a construction that typically conveys rejection. In addition, because of their concrete definitions, negative constructions can be detected and classified automatically in large corpora following lexical and syntactic heuritics. For instance, rather than manually annotating sentences that express rejection, it is relatively easier to automate the process by searching for utterances containing the verb *want* modified

224 by negative morphemes.

225     Note that the aforementioned approach attends to negative constructions at the
226 sentence level that would convey the communicative functions of interest directly. One
227 downside of including just the sentence level is that it may systematically underestimate
228 children's production of these functions using negation. The reasons are twofold. First, due
229 to early limited developmental capacity, children produce shorter forms before longer ones
230 (e.g. mean length of utterance has been used predominantly as an index of syntactic
231 development at least in the earlier stage (Brown, 1973)). Therefore, they can express a
232 communicative function like rejection when they use a simple *no* as a response to the
233 question "do you want an apple?" before they can produce the full construction "I don't
234 want that." Additionally, when being asked "do you not want some snacks," a question where
235 the head verb is already modified by the negative morpheme *not*, children might still respond
236 with *no*, as in "no I don't want snacks." In these instances, *no* serves as a response particle
237 which is used in isolation to anaphorically negate the content of the previous utterance. In
238 other words, these negative discourse particles let children express different functions without
239 actually producing them in more complex syntactic structures, especially when they have
240 limited production capacity at the beginning of the developmental trajectory.

241     In addition, examiniations of production at the sentence level possibly falls short when
242 trying to "estimate" children's knowledge of negation more broadly (e.g. comprehension).
243 Imagine a scenario where the parent says "don't put your toys on the floor" and the child
244 says "no mommy." The parent's utterance consists of a negative construction that conveys
245 the communicative function of prohibition, whereas the child indicates their understanding
246 of this function via a negative response particle. While our focus here is the production
247 trajectory, we consider that it would be ideal to include or at least discuss cases as such
248 when possible, in order to gain better understanding of the development of negation in child
249 speech more generaly.

250         With the reasoning described above, besides investigating negative constructions at the

251   sentence level, we also examined children and parents' use of *no* as a response particle at the

252   discourse level.

Table 4

*Negative constructions used in this study that typically convey communicative functions studied in previous functional accounts of negation development.*

| Function | Negative morpheme combines with | Examples (negative) |
|---|---|---|
| Rejection | *like/want* | *I **not** like it*; ***not** want it* |
| Non-existence | *there*-expletive | *there is **no** soup* |
| Prohibition | imperative subjectless *do* | *do **not** spill milk* |
| Inability | *can* | *I can****not*** zip it* |
| Labeling (Denial) | nominal/adjectival predicates | *that's **not** a crocodile*; *it's **no** interesting* |
| Epistemic | *know/think/remember* | *I **not** know/think/remember* |
| Possession | *have*/possesive pronouns | ***not** have the toy*; ***not** mine* |

## Data and preprocessing

For child speech corpora in English, we turned to the CHILDES database (MacWhinney, 2000)[1] and selected data of English speaking children with typical development within the age range of 12-72 months. Parents' and children's utterances were extracted via the childes-db (Sanchez et al., 2019) interface using the programming language R. In order to obtain (morpho)syntactic representations for parents' and children's utterances, we used the dependency grammar framework (Tesnière, 1959). Part-of-speech (POS) tags for each token within an utterance were automatically derived with Stanza (Qi, Zhang, Zhang, Bolton, & Manning, 2020), an open-source natural language processing library; dependency relations for all utterances were acquired also in an automatic fashion using DiaParser (Attardi, Sartiano, & Yu, n.d.), a dependency parsing system that has been demonstrated to achieve excellent performance for at least written texts in English.

At the sentence level, we characterized the syntactic features of the negative utterances associated with each communicative function (Table 4), then classified utterances based on these features in a rule-based fashion with the help of POS information and syntactic dependencies. To decouple the development of the syntactic construction from the development of negation in that construction, we also examined the production of positive counterparts to each negative construction. The positive counterparts of our negative constructions share the same syntactic features (e.g., same head verb) but they have no negative morphemes ("I know" for "I don't know"). Although these positive constructions do not express the same communicative function as their negative counterparts, our main purpose for including them is to factor in the development of the syntactic construction without negation as references.

At the discourse level, we need to analyze the negative constructions that the discourse

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[1] Code and data are in quarantine at https://thegoodplace.com

277   particle *no* stands for (or respond to in cases like prohibition, as discussed in the previous

278   section). To achieve this, we selected utterances that started with negative discourse

279   particles like "no no I like it," where the dependency relation of these discourse particles is

280   "discourse" by the dependency parser. We also included cases with just one or duplications of

281   the discourse particles ("no no no"). For each negative utterance identified this way, we

282   extracted the previous utterance (the antecedent) in the discourse context. For child speech,

283   we included interactions (antecedent + utterance with negative discourse particle) where

284   antecedents were produced by either the parents or the children themselves. For parent

285   speech, we only included interactions where the antecedent was produced by children. We

286   then applied the same analyses performed to sentence level constructions to these antecedent

287   utterances. The assumption is that the negative discourse particles are (mostly) implicitly

288   negating the content of their discourse antecedents. Therefore the antecedent utterances here

289   could follow structures of both the negative constructions or their positive counterparts.

290   This means that for each coummunicative function, the antecedents analyzed at the

291   discourse level constitute a subset of those analyzed at the sentence level. With that being

292   said, we are not exactly re-investigating the negative constructions at the sentence level, but

293   rather take this as one way to examine what the response particles are capturing.

294   **Measures**

295       We took age as a proxy for children's developmental stage and divided the 12-72

296   months range into monthly bins. We used the following two metrics to measure the

297   production level of every communicative function at each age bin. First, we defined the ratio

298   $f_{c,t}$ for construction $c$ and age bin $t$ as the number of utterances in construction $c$ and age

299   bin $t$ divided by the total number of utterances produced at age bin $t$. For example, at age

300   30 months, children produced a total of 81,302 utterances, out of which 391 were classified as

301   rejections. Therefore the ratio of rejection at 30 months is $391/81{,}302 = 0.005$.

$$f_{c,t} = \frac{n_{c,t}}{n_t}$$

Second, we borrowed the measure of "cumulative (moving) ratio" from the analysis of time series data (Wei, 2006). We defined the cumulative ratio $F_{c,t}$ for a construction $c$ at age bin $t$, as the sum of the number of utterances produced with construction $c$ from the first age bin to age bin $t$, divided by the sum of all utterances produced between the first age bin and age bin $t$. For instance, up to age 30 months, children in our corpus produced 721,748 total utterances, out of which 2,166 were instances of rejection. Therefore, the cumulative ratio of rejection at age 30 months is $2{,}166/721{,}748 = 0.003$. The cumulative ratio has the advantage that at each age bin, it takes into account the production in previous age bins. Assuming that children accumulate linguistic knowledge throughout their development, this measure provides a more realistic and stable measure of children's productive capacity at each age.

$$F_{c,t} = \frac{\sum_{i=1}^{t} n_{c,i}}{\sum_{i=1}^{t} n_i}$$

The two ratios mentioned above were calculated for negative constructions (and their positive counterparts) at the sentence and discourse levels for children as well as parents. With that being said, for the sake of presentations, our figures focus on the results of cumulative ratios. In addition, in this study we use parents' speech as a benchmark for children's development. Therefore, the subfigures within each figure contrast children's production to that of parents' at the corresponding age of the children.

**Growth curve analysis**

Besides the descriptive measures described above, in order to add more statistical rigor to our characterization as well as comparison of the overall production trajectories of different negative constructions, we adopted growth curve analysis (Kemper, Rice, & Chen, 1995). In particular, based on the observations for every negative construction in child speech derived from corpora (see Results), we adopted Bayesian logistic growth curve to

326  model children's *cumulative* production, $F_{c,t}$, at a given monthly age bin $t$.

327  $$F_{c,t} = \zeta + \frac{\delta - \zeta}{1 + exp(\gamma(t - \alpha))}$$

328  This logistic growth function consists of four parameters, where $\zeta$ indicates the lower

329  bound of production (minimum production for the construction investigated in child speech),

330  $\delta$ denotes the asymptote level of development (maximum cumulative production ratio that

331  could be reached), $\gamma$ estimates the maximum production growth rate, and $\alpha$ reflects the age

332  at which one-half of the development is achieved. The function draws a pattern where the

333  beginning of the development is slow, followed by rapid growth to one-half of the

334  development, then followed by a slow phrase of growth until the asymptote level is reached.

335  In our implementation, we used the statistical package *brms*. We set $\zeta$ to have a value

336  of zero; in other words, we did not attempt to make any assumption regarding the minimum

337  capacity of children's production, and whether certain negative constructions would be

338  produced after all. The prior for both $\delta$ and $\gamma$ followed a beta distribution, whereas the prior

339  for $\alpha$ followed a normal distribution with a mean of 42 (given that the age range of interest

340  here is between 12 to 72 months) and a standard deviation of 1.

341  $$\delta \sim Beta(2, 2)$$

342  $$\gamma \sim Beta(2, 2)$$

343  $$\alpha \sim N(42, 1)$$

344  Due to the fact that the production data extracted via our corpus methods is not

345  enough to capture the developmental paths of individual children, the logistic curves were fit

346  at the population level for each communicative function. The assumption here is that

347  individual differences on average in terms of the production of each function at both

348  syntactic and discourse level are small. Specifically, for each communicative function in child

349  speech, we applied one logistic curve to the negative constructions, one to their positive

counterparts, and one to the discourse antecedents. Each model ran 4 chains with 5000 iterations in each chain, with the first 500 iterations as burn-in samples; 95% credible intervals for each parameter were derived from their respective posterior distribution.

## Results

In this section, we describe the results for each communicative function and its associated negative constructions.

**Rejection.** For instances of "rejection" and their positive counterparts, we selected utterances in which the lemma of the head verb of the phrase was either *like* or *want*. For negative instances, the head verb is modified by one of the three negative morphemes *no*, *not* or *n't*, whereas cases including the same head verb but without negation were classified as positive (Table 5). In particular, the negative utterances included cases in which the speakers describe their own desires with or without an auxiliary verb, examples that express rhetorical inquiries of desires from one interlocutor to another, and instances where the speaker is describing the desires of somebody else. Our search critiera for this function led to a total of 20,641 negative utterances (child: 9,398; parent: 11,243), and a total of 180,881 positive utterances (child: 63,427; parent: 117,454).

Table 5

*Examples of sentence-level rejections and their positive counterparts in children's speech.*

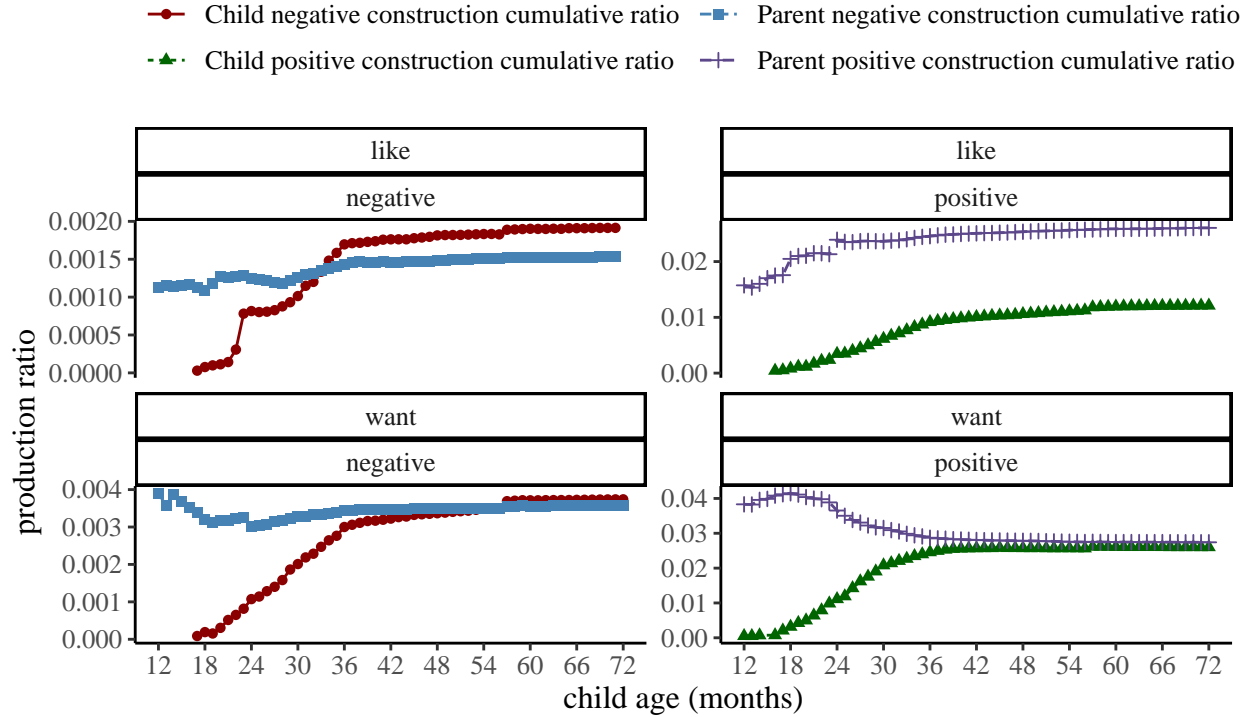| Rejection (Negative) | Positive counterpart |
| --- | --- |
| *I **no** like sea* | *she likes cheese* |
| *do**n't** wanna go* | *I want it* |
| *do**n't** you wanna try it* | *I wanna have that* |
| *Sarah does**n't** like that either* | *she likes this one* |

*Figure 1*. Cumulative ratios for the production of rejection at the sentence level for children between 12 to 72 months of age, and their parents. The y-axes are scaled differently for the panels to accommodate differences in production ratios.

366    Starting with our analysis at the sentence level, Figure 1 shows the cumulative ratios of

367 parents' and children's instances of rejections and their positive counterparts (y-axis) with

368 age along the x-axis. Overall, we see a similar pattern of production for rejection whether the

369 head verb is *want* or *like* in child speech. Comparing the cumulative ratios between parents

370 and children, children's production of rejection gradually increases between the ages of 18

371 and 36 months. After about 36 months of age, children's production of these constructions

372 starts to become relatively constant and close to parent levels. In all age bins, the

373 production ratio for negative utterances was lower than that for their positive counterparts.

374    At the discourse level, we investigated discourse interactions (antecedent + utterance

375 with negative discourse particle) in which the antecedent has one of the head verbs *like* or

376 *want*, yet the head verb does not have to be modified by negative morphemes (Table 6). We

377  found a total of 11,021 such utterances (child: 7,903; parent: 3,118). As shown in Figure 2,

378  children's production of *no* to convey rejection increases regularly from the age of 18 - 36

379  months.[2] Overall, discourse-level rejection is produced more frequently in child speech

380  compared to parent speech.

Table 6

*Examples of discourse-level rejections in children's and parents' speech.*

| Antecedent | Utterance |
| --- | --- |
| Parent: *I want you to try it* | Child: ***no no no*** |
| Parent: *would you like to go* | Child: ***no no*** |
| Child: *I do**n't** like that* | Parent: ***no** honey you have to try it* |
| Child: *I want it* | Parent: ***no** this is not for you* |
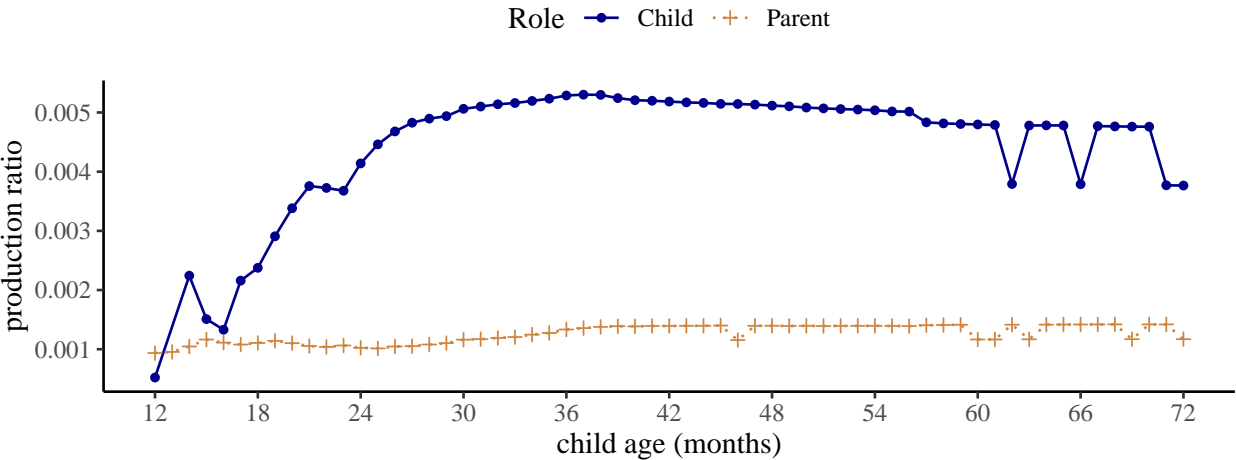


*Figure 2*. Cumulative ratios for the production of rejection at the discourse level for children between 12 to 72 months of age, and their parents.

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[2] For each communicative function, at the discourse level we also examined cases of different subtypes (e.g., different head verbs) separately; though due to data sparsity issues, we collapsed these instances for our final analyses.

381 **Non-existence.** For the function of non-existence, we searched for the English

382 expletive construction and extracted utterances that had *there*-expletives, followed by a

383 copula, and a noun phrase (phrases headed by either nouns or pronouns). We classified

384 utterances where the predicate was modified by negation as negative, and the rest as

385 positive. This led to a total of 1,983 negative utterances (child: 498; parent: 1,485), and

386 35,287 positive utterances (child: 8,385; parent: 26,902).

Table 7

*Examples of sentence-level non-existence and positive counterparts in children's speech.*

| Non-existence (Negative) | Positive counterpart |
| --- | --- |
| *there's **no** (more) water* | *there are books* |
| *there is**n't** it* | *there is it* |
| *there's **no** more cheese* | *there is the toy* |
| *there is **no** food* | *there is an apple* |

387 At the sentence level, children produce negative constructions to express non-existence

388 less frequently than they do for the positive counterparts. As presented in Figure 3, the

389 cumulative ratio for the production of non-existence increases mostly from 18 to 36 months.

390 Then around and after 36 months of age, children's production gradually reaches a stable

391 ratio but stays below parents' level. Notice that there appears to be slight fluctuations of

392 cumulative ratios between the age of 19 and 25 months in child speech. A closer inspection

393 of the data reveals that within that age range, the frequency of negative utterances at most

394 ages is either one or zero. Therefore as the number of total utterances increases along the

395 developmental trajectory, the cumulative ratio for non-existence utterances actually
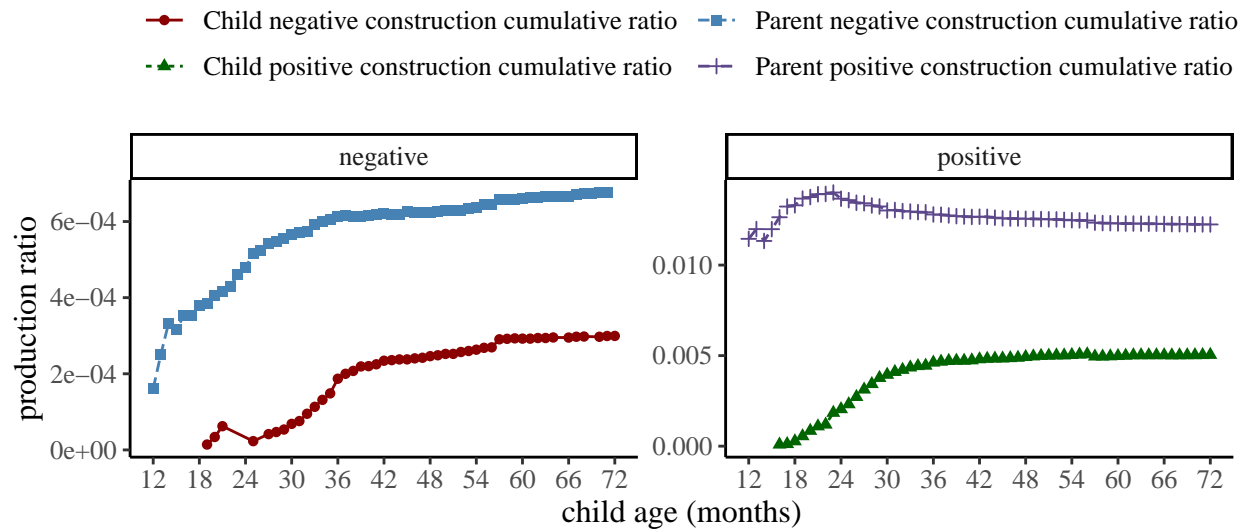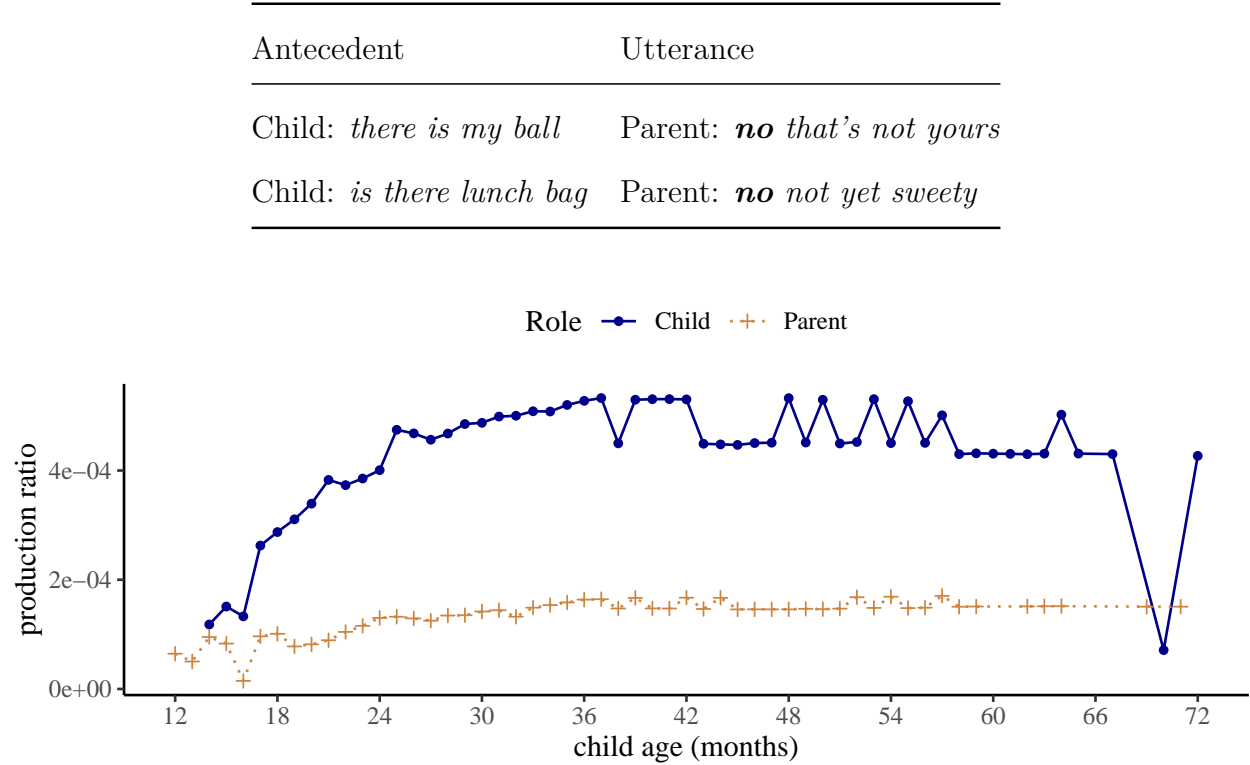
396 decreases in this brief period.

*Figure 3*. Cumulative ratios for the production of non-existence at the sentence level for children between 12 to 72 months of age, and their parents. The y-axes are scaled differently for the panels to accommodate differences in production ratios.

For non-existence at the discourse level, we applied similar selection criteria and extracted utterances (negative and positive) with existential constructions in their antecedents (Table 8). This led to a total of 1,202 utterances (child: 828; parent: 374). As Figure 4 shows, there is an increase in children's responses with *no* to parents' existential utterances between the ages of 18 and 36 months. After 36 months, despite the fact that ratios show fluctuations, the cumulative ratios of children's production seem stable and similar. Therefore with non-existence, both sentence-level and discourse-level analyses point to substantial development in the age rage of 18-36 months.

Table 8

*Examples of discourse-level non-existence in children's and parents' speech.*

| Antecedent | Utterance |
| --- | --- |
| Parent: *is there a bunny* | Child: ***no no*** *bunny* |
| Parent: *is there a table* | Child: ***no no*** |

| Antecedent | Utterance |
|---|---|
| Child: *there is my ball* | Parent: **no** *that's not yours* |
| Child: *is there lunch bag* | Parent: **no** *not yet sweety* |



*Figure 4.* Cumulative ratios for the production of non-existence at the discourse level for children between 12 to 72 months of age, and their parents.

**Prohibition.** For constructions that typically convey prohibition, we extracted utterances that were labeled as "imperatives" in the CHILDES database. In particular, we selected instances where the head verbs do not take any subjects. As before, cases without any negative morphemes are considered as positive. For negative constructions, we chose structures where the negative morphemes are combined with the auxiliary verb *do* and they together modify the head verbs of the sentences. In order to not have overlap with rejection, non-existence, epistemic negation and possession (see below), our search excluded utterances where the head verb had any of the following lemma forms: *like, want, know, think, remember, have.* This resulted in a total of 1,056 negative utterances (child: 303; parent: 753), and 25,542 positive utterances (child: 8,659; parent: 16,883).

Figure 5 demonstrates the cumulative ratios of prohibition and their positive

416 counterparts in parents' and children's production at the sentence level. In both child and

417 parent speech, negative constructions for prohibition are consistently produced less

418 frequently than their positive counterparts. Children produce negative imperatives more and

419 more often between 24 and 36 months. In comparison, the cumulative ratio in parent speech

420 gradually decreases at the beginning when children are between 12 - 24 months. Yet overall,

421 children's production remains consistently lower than parents' production of prohibition.

422 This might be due to the social nature of parent-child interactions, in which it is more likely

423 for parents to explicitly command and direct children's actions than the other way round.

Table 9

*Examples of sentence-level prohibition and positive counterparts in children's speech.*

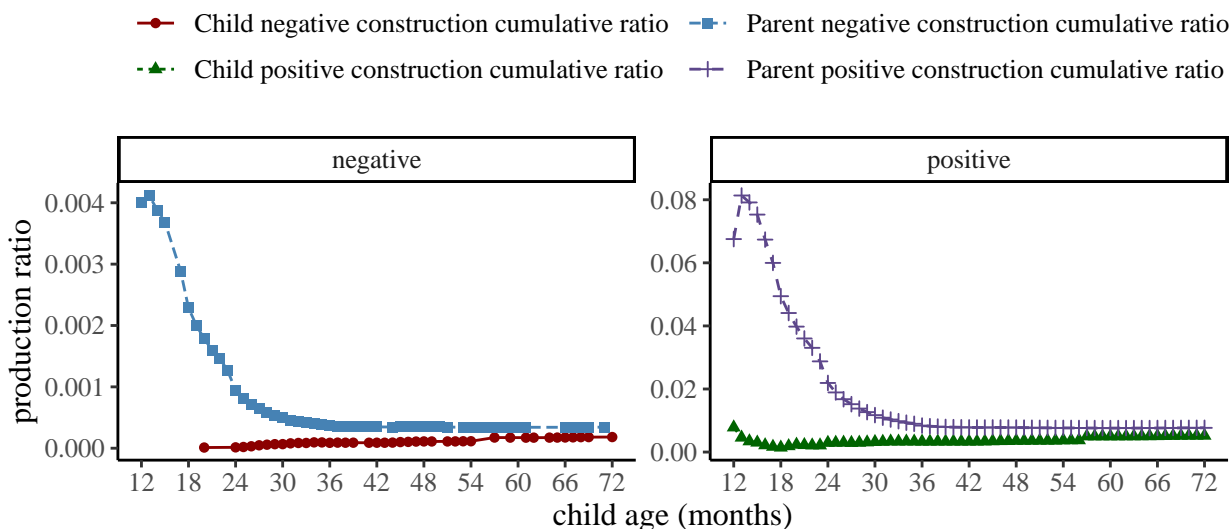| Prohibition (Negative) | Positive counterpart |
|---|---|
| *do**n't** blame Charlotte* | *cook it* |
| *do**n't** do that* | *try this* |
| *do **not** touch that* | *drink your water* |
| *do **not** break it* | *come here* |

*Figure 5*. Cumulative ratios for the production of prohibition at the sentence level for children between 12 to 72 months of age, and their parents. The y-axes are scaled differently for the panels to accommodate differences in production ratios.

At the discourse level, we selected utterances where *no* serves as a discourse response particle to antecedents that were subjectless imperatives headed by a verb. Again we excluded cases where the head verbs have any of the following lemmas: *like, want, know, think, remember*, and *have*. We would like to point out that in these instances, children's (and parents') production of *no* is not necessarily negating the content of the antecedent prohibition. Instead we simply included these cases as lens to probing children's negative responses to imperatives, and also to be consistent with our analyses of the negative constructions of other communicative functions. Our search resulted in a total of 107 utterances (child: 65; parent: 42). As shown in Figure 6, both children's and parents' usage of negation as a response particle to imperatives gradually decreases before 36 months, then stays relatively stable after. Nevertheless, given the extremely small sample size here, these observations are not conclusive.

Table 10

*Examples of discourse-level prohibition in children's and parents' speech.*

| Antecedent | Utterance |
|---|---|
| Parent: *put away your toys* | Child: ***no*** *mommy I like these* |
| Parent: *do**n't** put it there* | Child: ***no*** *I really want to* |
| Child: *give it to me* | Parent: ***no*** *not right now* |
| Child: *try it* | Parent: ***no no*** *please* |
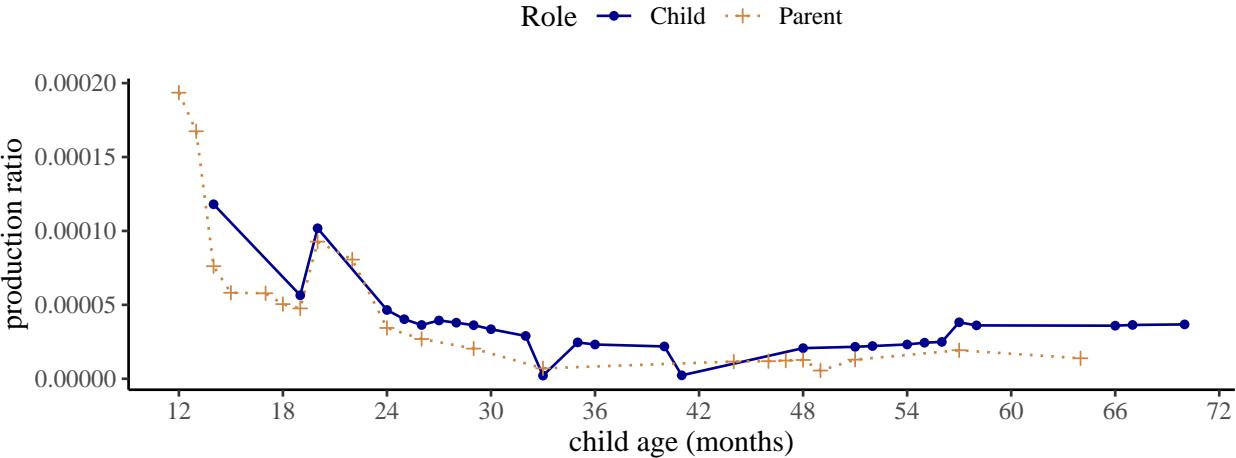


*Figure 6*. Cumulative ratios for the production of prohibition at the discourse level for children between 12 to 72 months of age, and their parents.

**Inability.** For the function of inability, we analyzed instances with head verbs that are modified by the modal auxiliaries *can* and *could*. If the head verb was also modified by a negative morpheme, we classified it as negative. Otherwise, we considered it positive. Depending on the larger context, the interpretation of utterances such as "can't go yet" and "this can't go in the box" could be deontic (e.g., "not allowed to go yet"). Given the automatic fashion of our approach, in order to limit the number of cases that potentially yield readings other than (in)ability, we excluded cases without a subject or with subjects that were not first person singular *I*. This led to 7,115 negative utterances (child: 3,917;

444 parent: 3,198), and 14,433 positive utterances (child: 7,589; parent: 6,844). Table 11 shows a

445 few example of the cases we considered.

Table 11

*Examples of sentence-level inability and positive counterparts in children's speech.*

| Inability (Negative) | Positive counterpart |
|---|---|
| *I ca**n't** see* | *I could do it* |
| *I ca**n't** go* | *I could help it* |
| *I can **not*** | *I can try* |
| *I can **not** do it* | *I can put it back* |

446      Figure 7 shows cumulative ratios of parents' and children's production of constructions

447 that convey (in)ability. Similar to previous constructions, positive instances are generally

448 more frequent than negative ones. Children produce inability more and more frequently

449 between 18-36 months. After 36 months, their production is gradually becoming stable and
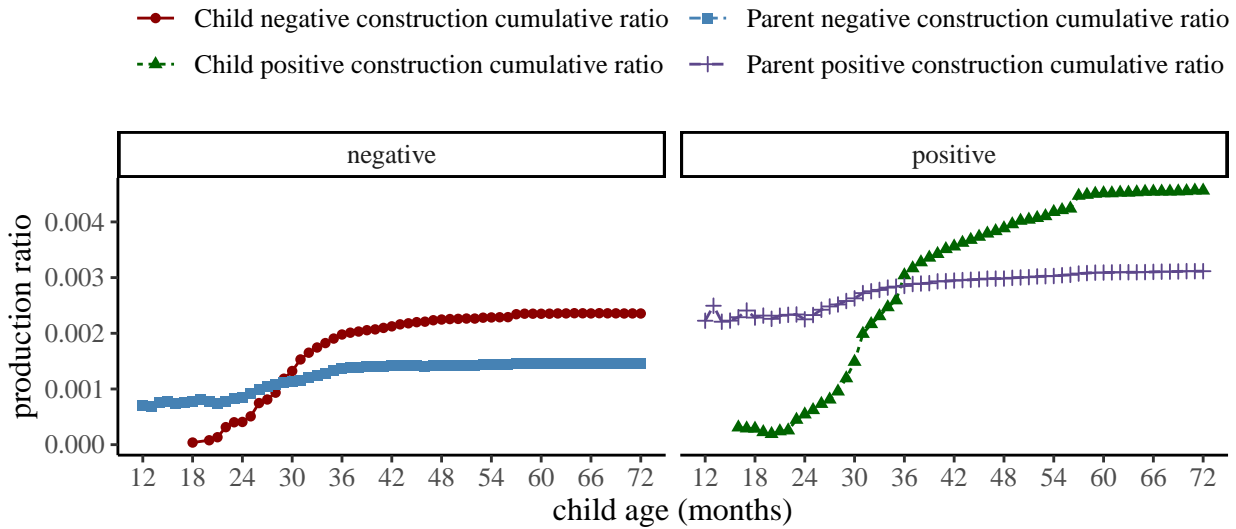
450 higher than parents' production level.

*Figure 7*. Cumulative ratios for the production of inability at the sentence level for children between 12 to 72 months of age, and their parents. The y-axes are scaled differently for the panels to accommodate differences in production ratios.

Table 12

*Examples of discourse-level inability in children's and parents' speech.*

| Antecedent | Utterance |
| --- | --- |
| Parent: *I can do it for you* | Child: ***no no*** |
| Parent: *I ca**n't** see* | Child: ***no*** *try again* |
| Child: *I can pour this* | Parent: ***no no*** *please* |
| Child: *I ca**n't** finish* | Parent: ***no*** *you have to* |

⁴⁵¹    At the discourse level, we chose utterances with the negative particle *no* in response to

⁴⁵²  antecedents that had a similar structure to the inability construction defined at the sentence

⁴⁵³  level. In these interatctions, *no* is not exactly negating the content of the antecedents

⁴⁵⁴  neither; however, similarly to our motivation for analyzing prohibition at the discourse level,

⁴⁵⁵  we included these instances to investigate children's (and parents') negative response to

456 (in)ability more broadly. This yielded a total of 1,275 negative utterances (child: 621; parent:

457 654). Figure 8 presents the cumulative ratios for parents' and children's production of

458 discourse-level inability. It appears that children's production gradually increases from 24 to

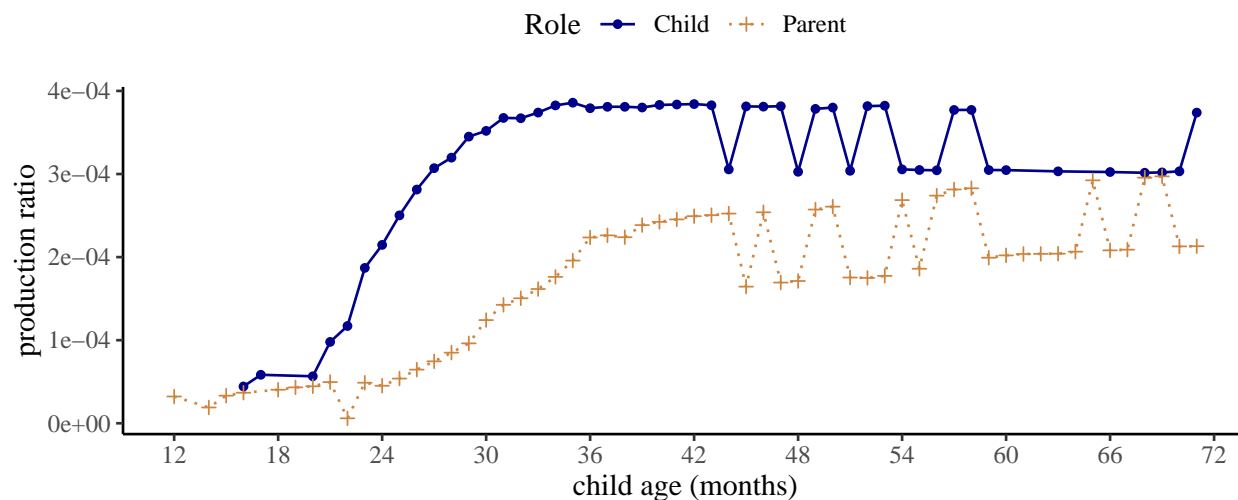459 36 months and stabalizes after 36 months at a similar rate to that of parent's.



*Figure 8*. Cumulative ratios for the production of inability at the discourse level for children between 12 to 72 months of age, and their parents.

460 **Labeling.** To capture the function of labeling at the sentence level, we concentrated

461 on copula structures in which the predicate is a nominal or an adjectival phrase. Specifically,

462 the nominal predicates exclude possessive pronouns (e.g., "mine") as well as nominals with a

463 possessive dependent (e.g., "my book") in order to not overlap with the communicative

464 function of possession (see Possession below). We considered instances where the predicate is

465 modified by negative morphemes as negative, and others as positive. To also avoid overlap

466 with cases of non-existence, none of the utterances contained expletives (e.g., "there is no

467 book"). This resulted in a total of 36,410 negative utterances (Child: 6,193; Parent: 30,217),

468 and 484,679 positive utterances (Child: 121,107; Parent: 363,572).

Table 13

*Examples of sentence-level labeling (negative) and positive counterparts in children's speech.*

| Labeling (Negative) | Positive counterpart |
|---|---|
| *that's not a farmer* | *this is a book* |
| *this is not the book* | *this is nice* |
| *I'm not a heavy baby Mum* | *it's a nice bowl* |
| *It's no good* | *she's pretty* |

Figure 9 shows cumulative ratios for parent's and children's production of the labeling construction at the sentence level. In both parent and children speech, the frequency of positive counterparts is consistently higher than that of negative labeling instances. Children's production of negative labeling increases between 18-36 months, and remains stable after then; though the production ratios remained lower than those of parents' production.
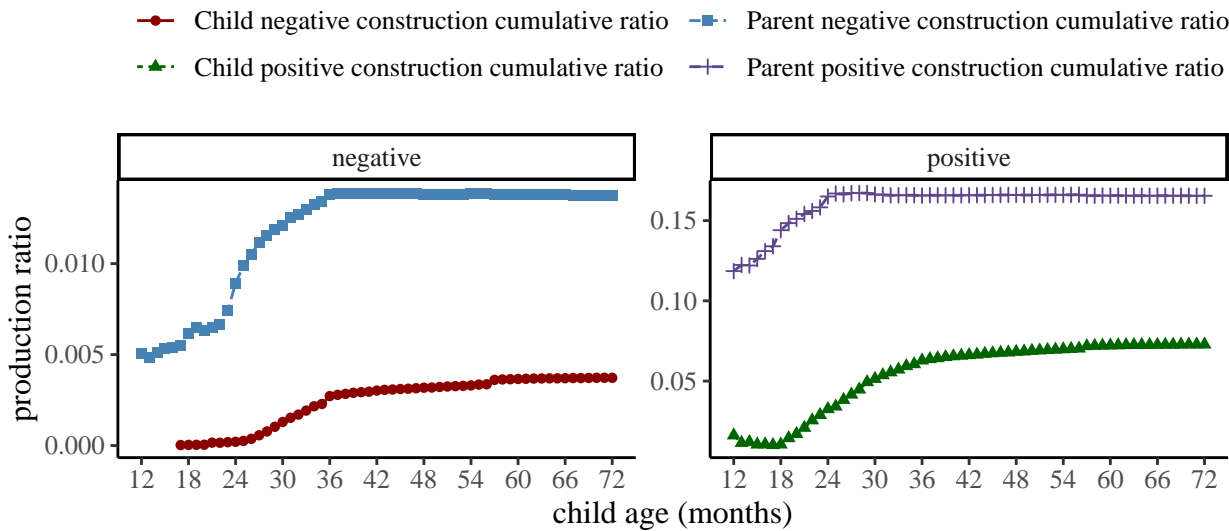


*Figure 9*. Cumulative ratios for the production of (negative) labeling at the sentence level for children between 12 to 72 months of age, and their parents. The y-axes are scaled differently for the panels to accommodate differences in production ratios.

<sup>475</sup> At the discourse level, we selected antecedent utterances with copula structures that
<sup>476</sup> combined with a nominal or an adjectival predicate (14). In total we found 18,037 utterances
<sup>477</sup> (Child: 12,501; Parent: 5,536). The cumulative ratios for labeling instances at the discourse
<sup>478</sup> level are illustrated in Figure 10. There is an increase in children use of *no* to negate labeling
<sup>479</sup> between 18 to 36 months. After 36 months, however, the production stays at a stable rate
<sup>480</sup> above parents level.

Table 14

*Examples of discourse-level labeling (negative) in children's and parents' speech.*

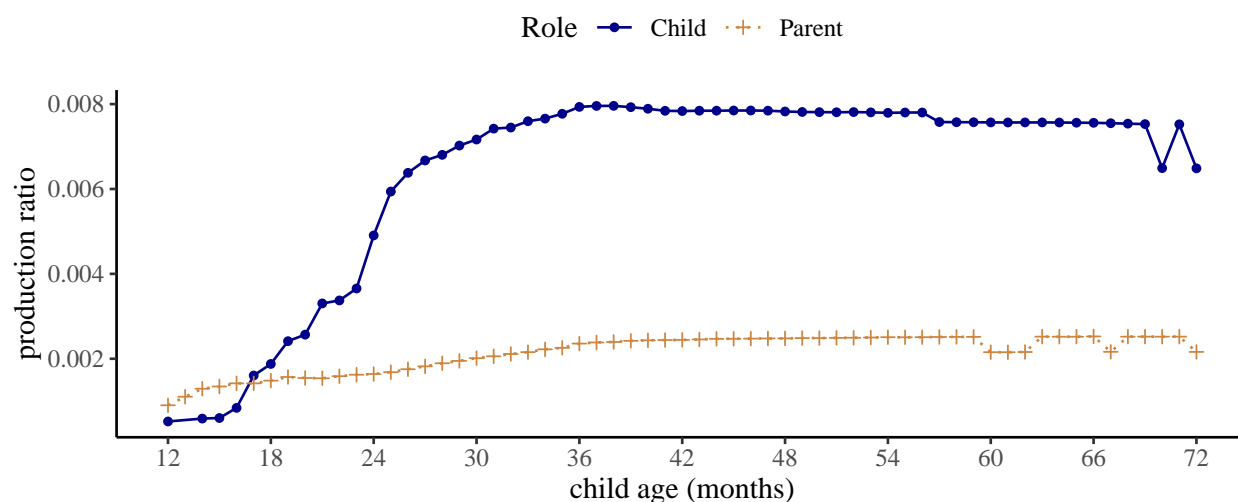| Antecedent | Utterance |
| --- | --- |
| Parent: *is this one good* | Child: **no** *it's not* |
| Parent: *are you a captain* | Child: **no** *I'm not* |
| Child: *that's the one* | Parent: **no** *it's the green one* |
| Child: *this is the key* | Parent: **no no** |



*Figure 10*. Cumulative ratios for the production of (negative) labeling at the discourse level for children between 12 to 72 months of age, and their parents.

481 **Epistemic Negation.** Previous studies have reported instances in which children

482 combined negative morphemes with mental state verbs such as *know, think*, and *remember* to

483 express "epistemic negation" (Choi, 1988). To define epistemic constructions, we also focused

484 on these three verbs. For sentence-level epistemic negation, we analyzed negative utterances

485 where these verbs were modified by negative morphemes, possibly after combining with an

486 auxiliary verb like *do*. Table 16 shows a few examples. Instances where the speaker asked

487 about or described the negative epistemic state of another speaker were also included,

488 leading to 31,696 negative utterances in total (child: 9,852; parent: 21,844). For the positive

489 counterparts, we selected instances with the same head verbs except that these verbs were

490 not modified by negation. This resulted in a total of 95,679 positive utterances (child:

491 16,322; parent: 79,357).

Table 15

*Examples of sentence-level epistemic negation and positive counterparts in children's speech.*

| Epistemic (Negative) | Positive counterpart |
| --- | --- |
| *I **not** know* | *I know* |
| *I did**n't** remember* | *she remembers* |
| *I do**n't** think so* | *he thinks this one is good* |
| *She does**n't** know this* | *She knows about this* |

492 Figure 11 shows the cumulative ratios of the epistemic construction as defined above in

493 parents' and children's speech at the sentence level. Across the three head verbs, children's

494 production increases substantially from 18 to 36 months then gradually becomes stable yet

495 still lower than parents' production level afterwards. The number of epistemic instances

496 headed by *know* is overall higher than the number of cases headed by either *remember* or

497 *think*, an observation that is consistent in both negative constructions and positive

498 counterparts. With that being said, the majority of negative constructions headed by *know*

499 are idiomatic expressions such as "I don't know" (51.66%) or "don't know" (13.73%).

500 Positive epistemic utterances are in general more frequent than negative ones, with the
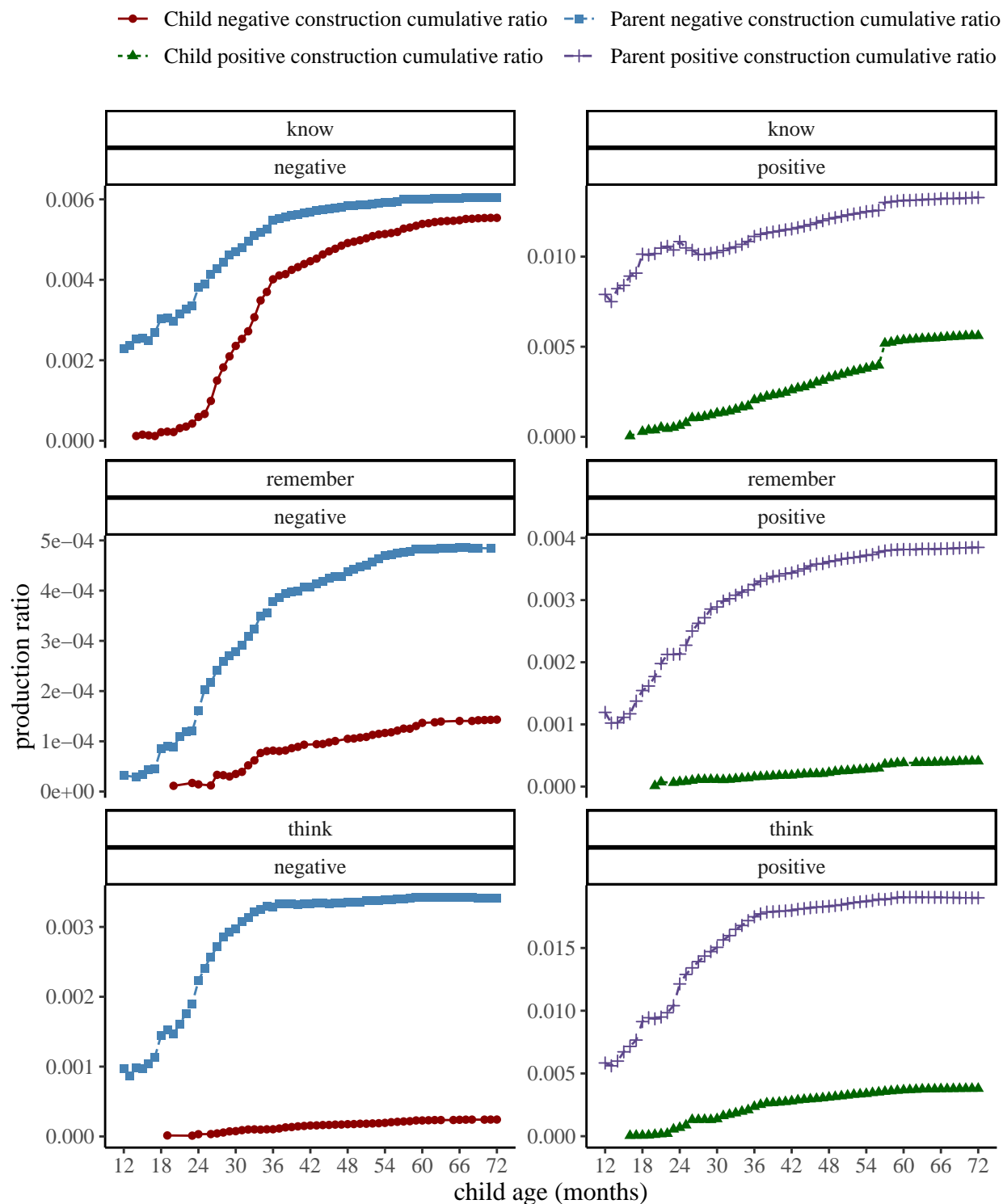
501 exception of *know* in child speech.

*Figure 11*. Cumulative ratios for the production of epistemic negation at the sentence level for children between 12 to 72 months of age, and their parents. The y-axes are scaled differently for the panels to accommodate differences in production ratios.

502       For epistemic negation at the discourse level, we examined interactions in which the

503  antecedent utterances took any of the three head verbs: *know*, *remember* and *think*, leading

504  to a total of 5,695 utterances (child: 4,303; parent: 1,392). As shown in Figure 12, children's

505  production of *no* to negate antecedent epistemic utterances increases rapidly between 18-36

506  months and is in general higher than the production ratio of parents'.

Table 16

*Examples of discourse-level epistemic negation in children's and parents' speech.*

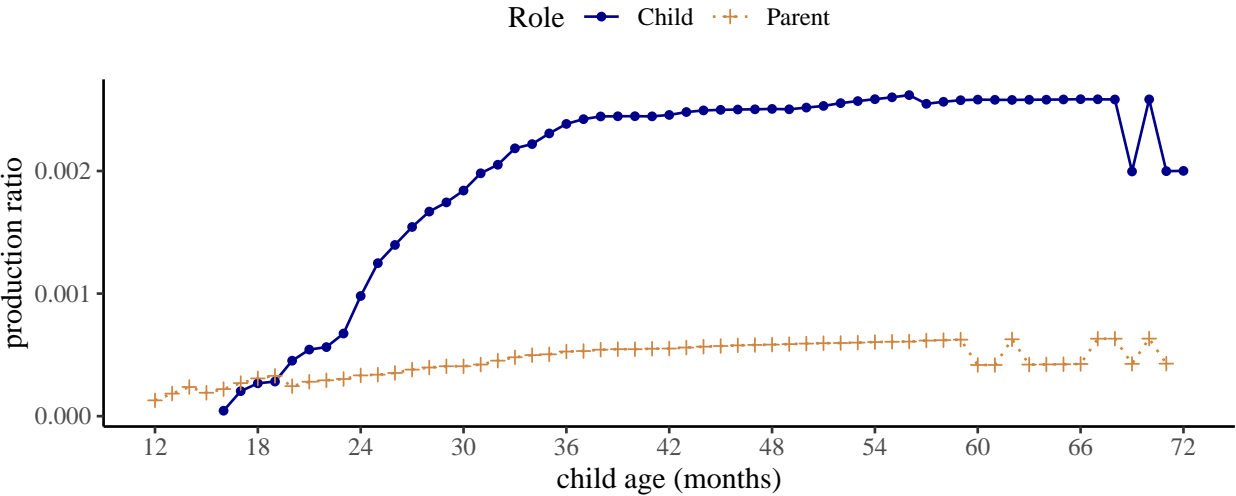| Epistemic (Negative) | Positive counterpart |
|---|---|
| Parent: *do you know* | Child: **no** |
| Parent: *do you remember* | **no** *I do**n't** remember it** |
| Child: *does she think so* | Parent: **no not** *really* |
| Child: *do they know it's today* | **no** *I do**n't** think so honey* |



*Figure 12*. Cumulative ratios for the production of epistemic negation at the discourse level for children between 12 to 72 months of age, and their parents.

507      **Possession.**   The last function we explored was possession. At the sentence level, for

508  negative structures we selected cases where negative morphemes were combined with

509 auxiliary verbs to modify head verbs with the lemma form *have*, and the POS tag of these

510 head verbs is all "VERB." We also included cases of which the syntactic head is a nominal

511 predicate; the nominal predicate can either be a possessive pronoun (e.g., "yours") or a noun

512 phrase with a possessive modifier (e.g., "her book"). Table 17 presents several examples.

513 The number of negative utterances subjected to analysis for this function is 8,892 (child:

514 2,830; parent: 6,062). Again the positive counterparts share similar structures except

515 without negation, leading to a total of 86,665 utterances (child: 27,730; parent: 58,935). One

516 thing to note here is that for the positive structures with the head verb *have*, we restricted

517 our search to instances where the head verb takes a direct object (with the dependency

518 relation *obj*). This is to avoid potential parsing errors of utterances such as *I have*, where the

519 verb could ambiguously be an auxiliary.

Table 17

*Examples of sentence-level possession (negative) and positive counterparts in children's speech.*

| Posession (Negative) | Positive counterpart |
| --- | --- |
| *I do**n't** have it* | *you have that* |
| *you do**n't** have my toy car* | *she has it* |
| ***not** mine* | *this is hers* |
| ***not** yours either* | *mine mine mine* |

520 Figure 13 presents cumulative ratios of possession construction at the sentence level.

521 Regardless of whether the utterances are negative or positive, the production trajectory in

522 child speech appears to have notable differences depending on the syntactic head. When the

523 instances are headed by *have*, children increase their production between 18-36 months, a

524 pattern that is present in both negative and positive constructions; yet children's production

525 ratio consistently stays below parents' level across the developmental path. For utterances

<sub>526</sub> headed by possessive pronouns, on the other hand, children's production increases rapidly

<sub>527</sub> between 18-24 months and stays above parents' production level as early as 24 months of age.
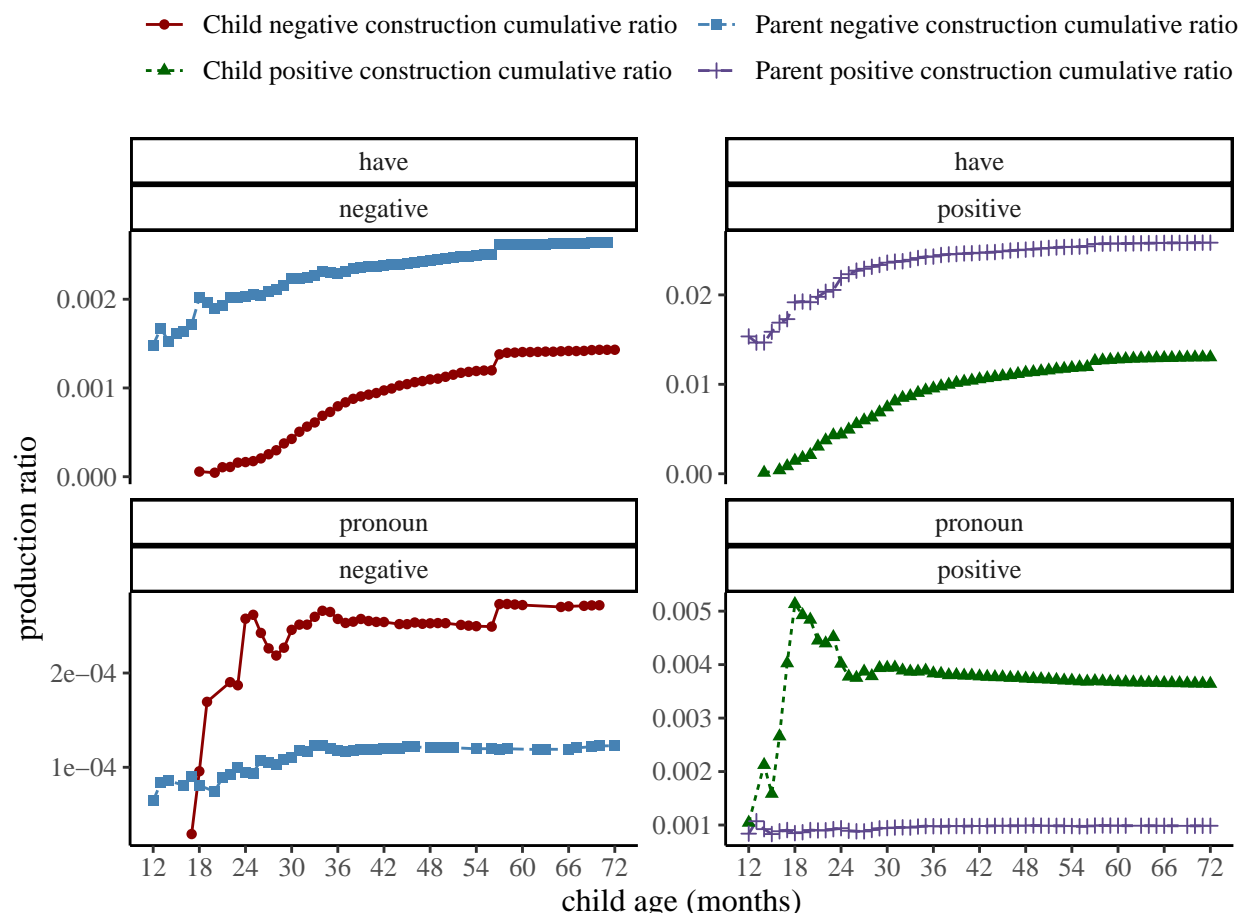


*Figure 13*. Cumulative ratios for the production of possession at the sentence level for children between 12 to 72 months of age, and their parents. The y-axes are scaled differently for the panels to accommodate differences in production ratios.

<sub>528</sub>     For discourse-level possessives, we selected antecedents of the negative response

<sub>529</sub> particle *no* which themselves had structures similar to the negative and positive

<sub>530</sub> constructions of possession at the sentence level (Table 18). Based on Figure 14, the overall

<sub>531</sub> patterns indicate that children's production of possession at the discourse level increases

<sub>532</sub> gradually within the age range of 18 to 36 months; and their production ratio is mostly

<sub>533</sub> higher than that of parents.

Table 18

*Examples of discourse-level possession (negative) in children's and parents' speech.*

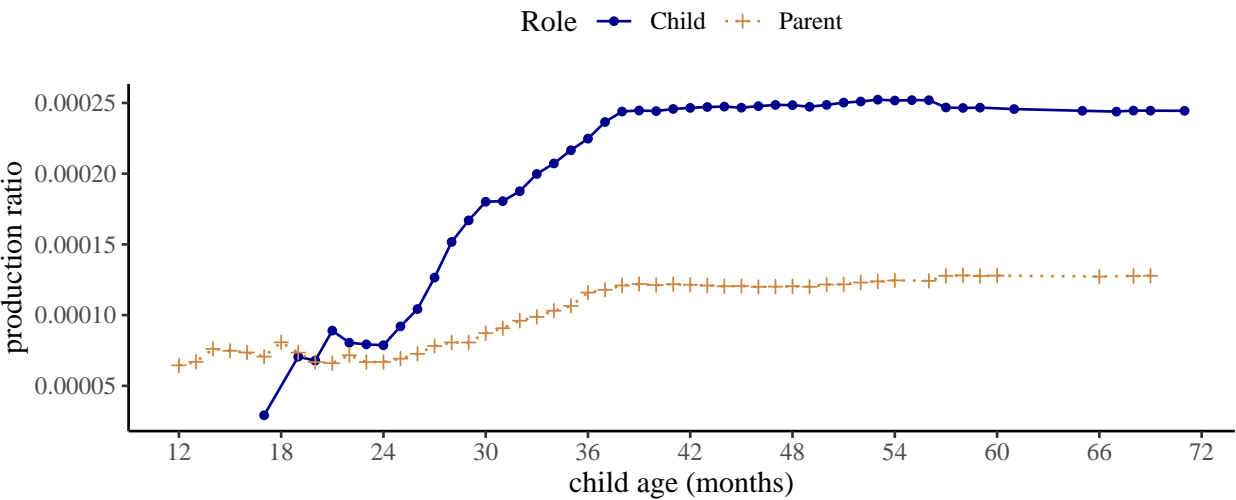| Antecedent | Utterance |
|---|---|
| Parent: ***not*** *yours* | Child: ***no*** *it's mine mine* |
| Parent: *do you still have that picture* | Child: ***no*** |
| Child: ***not*** *hers* | Parent: ***no no*** |
| Child: *mommy has it* | Parent: ***no*** *I do**n't*** |



*Figure 14*. Cumulative ratios for the production of possession at the discourse level for children between 12 to 72 months of age, and their parents.

**Analysis and Discussion.** In Figure 15, we present the cumulative ratios of all our negative constructions at the sentence level for children (left panel) and parents (right panel). It seems that parents produce most negative constructions at relatively constant rates across most of the age bins. Notable exceptions are labeling, epistemic, and prohibitions between 12-36 months. Parents seem to increase their production of labeling and epistemic constructions in this period and their production becomes more stable after 36 months. This obervation aligns with labeling and epistemic negation in child speech, which suggests that

the production patterns in child speech for these two functions may be more influenced by interactions with parents, and vice versa as children grow to be more conversant and interactive. On the other hand, prohibition starts as one of the most frequent constructions at 12-18 months of age and ends up as the least frequently used construction after around 30 months. One obvious reason for this trend may be that when children are younger, parents guide their actions through imperatives and commands much more frequently than later in the child's life.

By comparison, children start producing most constructions in the 12-18 age range. Two functions, non-existence and prohibition, seem to emerge at later ages than others. With non-existence, even though there are examples between 18-24 months, the cumulative production ratios are fluctuating and discontinuous, instead of demonstrating a slow and steady increase as seen in most of the other functions. As described in previous sections, the data for non-existence before 25 months based on our corpus search is relatively sparse; it is possible that with more examples a clearer pattern may arise. With prohibition, we see a relatively smooth pattern. Children begin to produce them more regularly between 24-30 months and its rate of production stays below parents' levels. One explanation for this pattern is that parent-child interactions do not provide many contexts for children to prohibit parents. Overall by 36 months of age, children's production of most constructions starts to become stable.
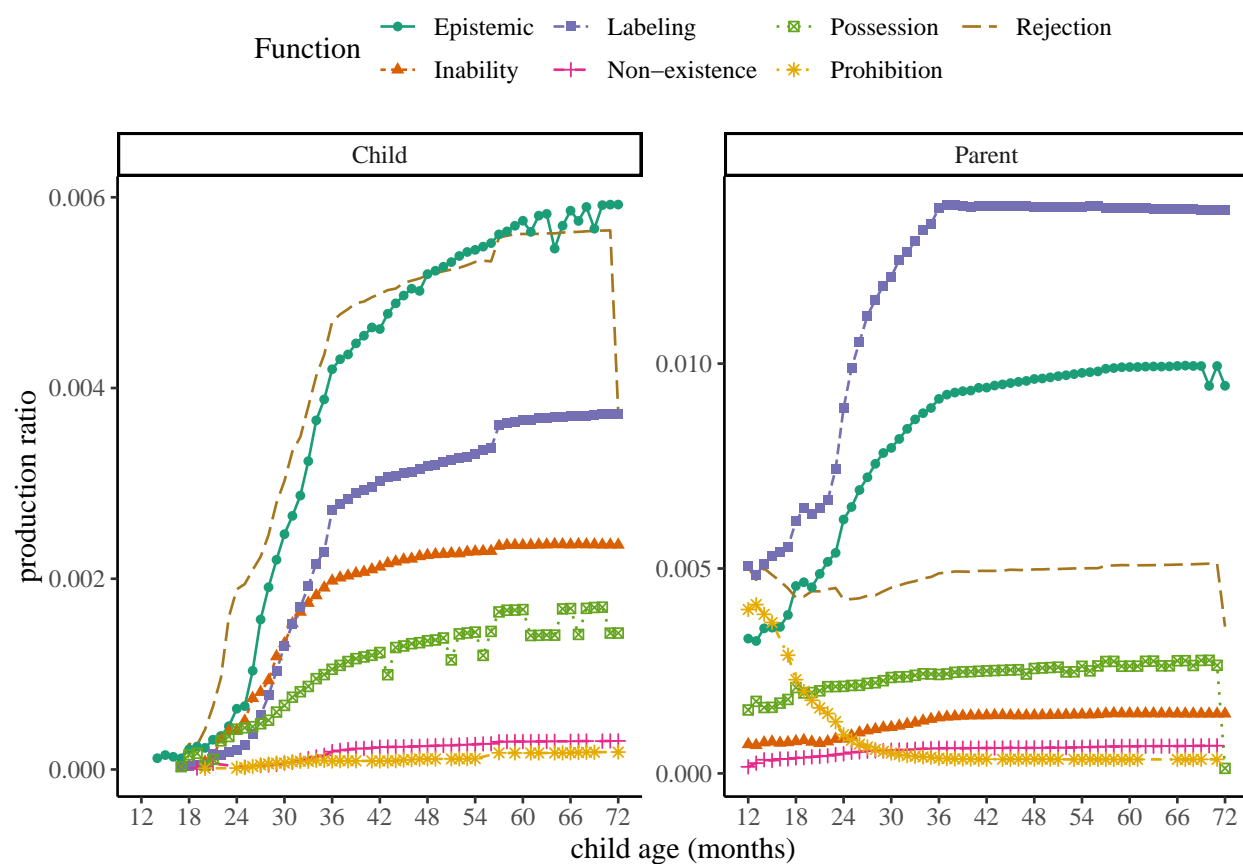
*Figure 15*. Cumulative ratios for all negative constructions at the sentence level.
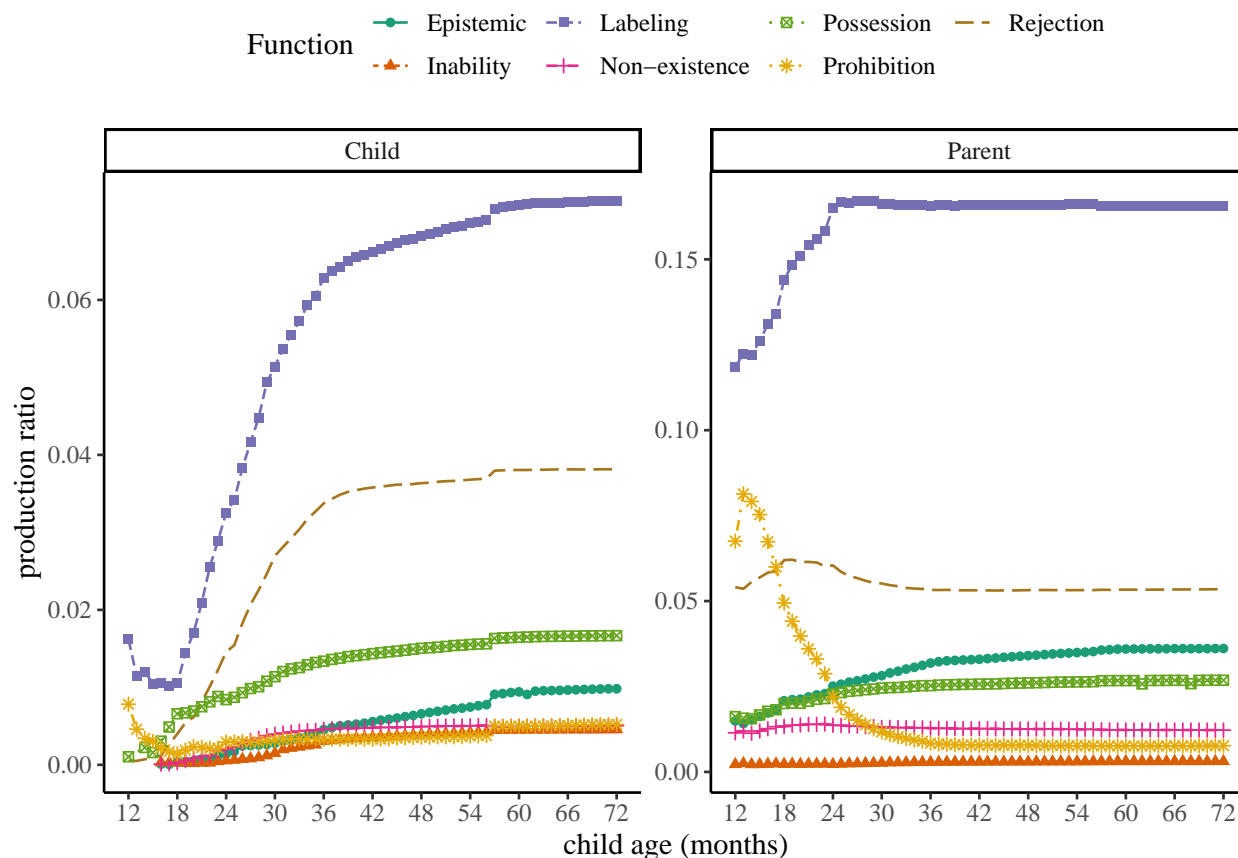
*Figure 16*. Cumulative ratios for the positive counpterparts to all negative constructions at the sentence level.

On the other hand, figure 16 shows the cumulative ratios of all positive counterparts to our negative constructions at the sentence level for children (left panel) and parents (right panel). The production of the positive instances in parent speech for almost all constructions is stable. Notable exceptions are labeling and positive counterparts to prohibitions (positive imperatives) between 12-30 months. Similar to negative instances of labeling, positive instances increase in frequency between 12-30 months but remain constant after. Positive prohibitions are produced much more frequently between 12-36 months, but their production decreases later. This pattern mirrors what we see in Figure 15 with (negative) prohibitions, that the usage of imperatives in interactions potentially becomes less necessary as children grow older.

Compared to parent speech, children start producing all positive counterparts to our negative constructions between the age range of 12-18 months. By 36 months, almost all positive constructions are being produced at a relatively constant rate close to parents' levels. Another noteworthy pattern is the relative high frequency of positive counterparts to prohibitions in the 12-24 months age period. In contrast to the production of (negative) prohibitions, positive imperatives are produced with high frequency even before 24 months of age. In other words, even though children do not frequently prohibit parents, they seem to be frequently ordering or commanding parents to do things for them; a conclusion that may not surprise many parents or caregivers.

Summarzing children's production patterns at the sentence level, it appears that regardless of whether the utterance is negative or positive, there is considerable similarity in terms of the developmental trajectories across the different communicative functions. Though there are discrepancies for cases of prohibition, overall the development of most negative constructions and their positive counterparts emerges between 12-18 months; their production increases substantially from 18 to 36 months, then starts to become stable (increase very slowly) after 36 months of age.

The fact that the developmental path for each function is comparable is additionally evident from results of the Bayesian logistic growth curve modeling, shown in Table 19. Minus the precise numerical values, the production of the negative utterances for all communicative function is estimated to reach a similar asymtotic level, without statistically significant differences between each other. The maximum growth rate as well as the age at which one-half of production is achieved are also comparable across functions, despite of whether the construction is negative.

Table 19

*Results for Bayesian logistic growth curve modeling in child speech at the sentence level; 95% credibal intervals for each parameter were derived from their own postierior distribution.*

| Function | Polarity | Asymptotic level | Growth rate | Age of 1/2 growth | $R^2$ |
|---|---|---|---|---|---|
| Rejection | Negative | 0.11 (0.01, 0.30) | 0.50 (0.09, 0.91) | 41.94 (40.03, 43.87) | 0.50 |
|  | Positive | 0.07 (0.01, 0.20) | 0.50 (0.09, 0.91) | 41.96 (40.02, 43.90) | 0.50 |
| Non-existence | Negative | 0.28 (0.04, 0.71) | 0.50 (0.10, 0.90) | 41.94 (40.01, 43.86) | 0.50 |
|  | Positive | 0.17 (0.02, 0.47) | 0.50 (0.09, 0.90) | 41.94 (40.00, 43.89) | 0.50 |
| Prohibition | Negative | 0.31 (0.04, 0.74) | 0.50 (0.10, 0.90) | 41.92 (39.99, 43.86) | 0.50 |
|  | Positive | 0.15 (0.02, 0.42) | 0.50 (0.09, 0.90) | 41.94 (40.07, 43.89) | 0.50 |
| Inability | Negative | 0.21 (0.03, 0.57) | 0.50 (0.10, 0.90) | 41.93 (39.99, 43.85) | 0.50 |
|  | Positive | 0.17 (0.02, 0.48) | 0.50 (0.08, 0.91) | 41.94 (40.03, 43.87) | 0.50 |
| Labeling (Denial) | Negative | 0.19 (0.02, 0.53) | 0.50 (0.09, 0.90) | 41.95 (39.98, 43.91) | 0.50 |
|  | Positive | 0.09 (0.01, 0.24) | 0.50 (0.09, 0.91) | 41.95 (39.92, 43.97) | 0.50 |
| Epistemic | Negative | 0.10 (0.01, 0.29) | 0.50 (0.09, 0.90) | 41.93 (39.99, 43.88) | 0.50 |
|  | Positive | 0.08 (0.01, 0.22) | 0.50 (0.09, 0.91) | 41.93 (39.95, 43.87) | 0.50 |
| Possession | Negative | 0.14 (0.02, 0.38) | 0.50 (0.09, 0.91) | 41.92 (39.95, 43.93) | 0.50 |
|  | Positive | 0.09 (0.01, 0.23) | 0.50 (0.09, 0.91) | 41.93 (40.00, 43.86) | 0.50 |

Finally, Figure 17 illustrates the cumulative ratios of all negative responses at the discourse level. Observations for parents' speech on the right again demonstrates a relatively constant rate of production after 36 months. Before 36 months, however, most constructions show a gradual increase with the exception of prohibition. Parents start with more frequent "*no!*"-responses to imperatives produced by children, but the frequency of these negative

598  responses drops to a relatively low and stable level after children are 36 months of age; this

599  pattern again corresponds to parents' production of subjectless imperatives in Figure 15 and
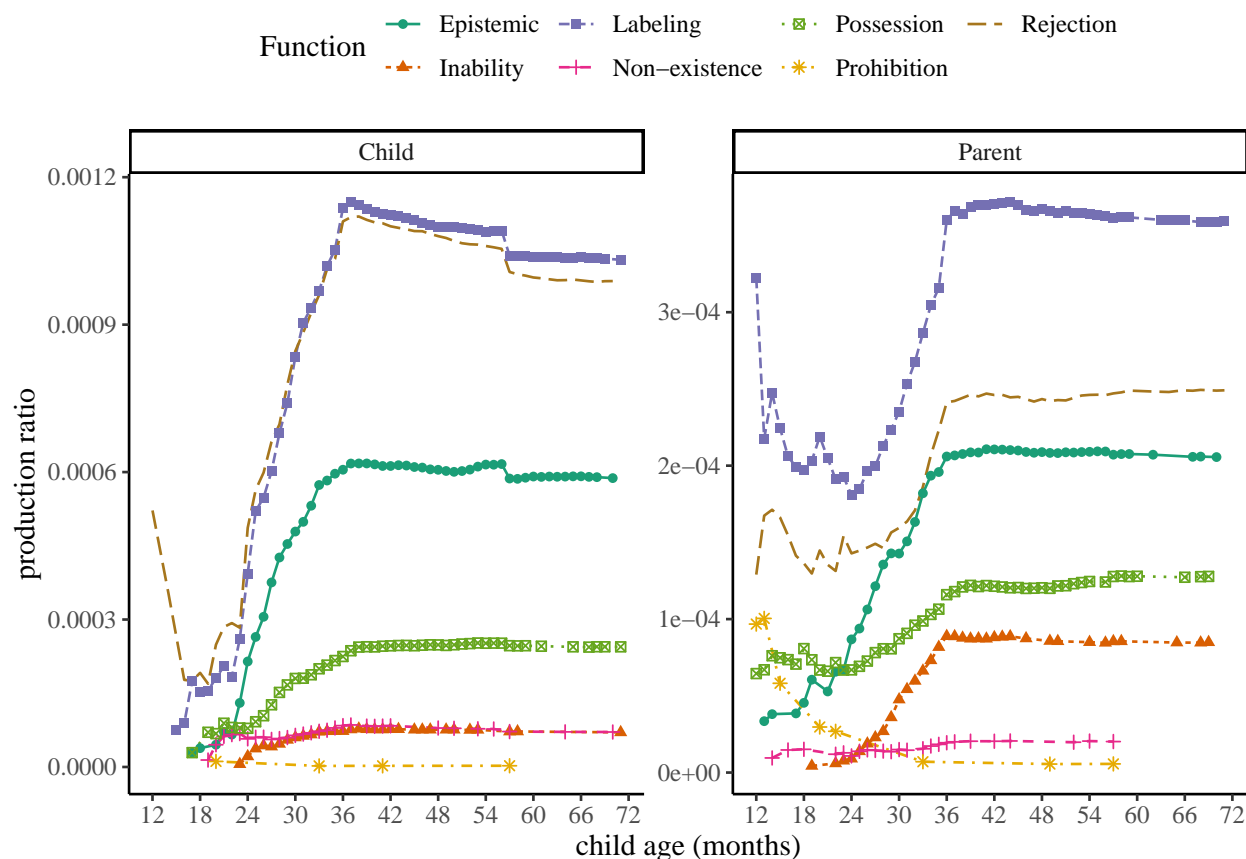
600  Figure 16.



*Figure 17*. Cumulative ratios for all negative constructions at the discourse level.

601      Looking at children's negative responses on the left panel, we see that production

602  begins for most functions around 18 months of age and by 36 months children are also

603  producing negative responses at a relatively constant rate; these patterns draw similarity to

604  those at the sentence level. The comparability of the developmental trajectories for different

605  communicative functions at the discourse level shown in Figure 17 is strengthened further

606  with the logistic growth curves. As demonstrated in Table 20, the asymptotic levels across

607  functions are estimated to be similar to each other; same holds for the maximum growth rate

608  and the age of one-half production growth. Furthermore, the results of the growth curve

609 models at the discourse level are also comparable to those at the sentence level presented in

610 Table 19, indicating overall similar production patterns between the two levels.

Table 20

*Results for Bayesian logistic growth curve modeling in child speech at the discourse level; 95% credibal intervals for each parameter were derived from their own postierior distribution.*

| Function | Asymptotic level | Growth rate | Age of 1/2 growth | $R^2$ |
| --- | --- | --- | --- | --- |
| Rejection | 0.17 (0.02, 0.45) | 0.50 (0.09, 0.90) | 41.95 (39.99, 43.88) | 0.50 |
| Non-existence | 0.22 (0.03, 0.58) | 0.50 (0.09, 0.90) | 41.95 (39.99, 43.91) | 0.50 |
| Prohibition | 0.23 (0.03, 0.59) | 0.50 (0.09, 0.90) | 41.94 (39.94, 43.88) | 0.50 |
| Inability | 0.25 (0.03, 0.66) | 0.50 (0.10, 0.90) | 41.93 (39.92, 43.90) | 0.50 |
| Labeling (Denial) | 0.15 (0.02, 0.42) | 0.50 (0.09, 0.90) | 41.96 (39.99, 43.92) | 0.50 |
| Epistemic | 0.19 (0.02, 0.51) | 0.50 (0.09, 0.91) | 41.94 (39.99, 43.85) | 0.50 |
| Possession | 0.25 (0.03, 0.65) | 0.50 (0.09, 0.91) | 41.94 (39.96, 43.86) | 0.50 |

## Conclusion

611

612 Using automatic annotations of large-scale corpora of child-parent interactions, we

613 presented production trajectories for seven negative constructions that tend to express

614 rejection, non-existence, prohibition, inability, labeling, epistemic states, and possession

615 (Table 1). The results suggest that the production of almost all these negative constructions

616 (except for prohibition) emerges before or around 18 months, and gradually increases within

617 the 18-36 months age range. Their production frequencies slowly become stable and regular

618 after 36 months and relatively comparable to parents' levels of production. These

619 observations hold at both the sentence level (Figure 15 and Figure 16) and the discourse

620 level (Figure 17). Our growth curve analyses demonstrate further the similarity in the

developmental path of the negative constructions for each of the functions, in particular with regards to their estimated asymtote level, maximum growth rate, and the age of one-half production growth. These findings suggest that negation possibly starts as a multi-functional concept; in other words, it develops from several communicative functions more or less at the same time. By contrast, our results do not provide clean-cut evidence for previous claims that the different functions of negation emerge and develop at different stages.

For future work, we would like to explore several directions. First, to more thoroughly examine and potentially model the developmental trajectories of negation in child production, certain production-specific factors (e.g., length of utterance, ease of pronunciation) should be taken into account as well in order to paint a more clear picture about the development of negation. Additionally, to avoid as much ambiguity resulted from the automatic parser as possible, we tried to be restrictive when identifying the negative constructions of interest in our study. This means that the structures analyzed here do not include all constructions modified by the three negative morphemes in English, such as instances where the syntactic head is a noun phrase that does not fall under the category of possession (e.g., "not table"). It would be worthwile for future studies to take upon these cases in order to investigate more broadly what lexical items negative morphemes co-occur with, and how the lexical diversity of these structures change along the developmental trajectory.

It is important to note that similar to prior studies, our conclusions are limited to negation in children's production. Systematic experiments testing children's comprehension of negative utterances with different communicative functions are necessary to better understand the origins and developmental trajectory of negation.

A different hypothesis is that from the start, negation is an abstract concept that can serve different communicative functions. The main task of the learner is to break the speech stream, detect negative morphemes like *no*, *not*, or *nt'*, and map them to this abstract meaning. She should then learn to use them appropriately in composition with other words

to convey the right communicative function in context. There is either no substantial conceptual development for a logical concept such as negation, or this development is complete by the time the process of form-meaning mapping starts. This account predicts that conceptualy speaking, different communicative functions should be learnable and expressable early on and around the same time. Any delays in the comprehension or production of negative constructions and functions must be due to lack of experience with that construction or limitations in children's productive capacity. Therefore, it is possible for communicative functions of negation to not be comprehended or produced in fixed and ordered stages. Children may vary considerably on what constructions or functions they comprehend or produce earlier.

There are a few theoretical and methodological caveats, however. Studies that hypothesize stages in the development of negation almost exclusively study children's productions. Our methods of data collection and analysis may also affect our ability to provide data for or against these hypotheses.

Nevertheless, there seems to be some consensus among researchers that the crucial period for the development of negation is the period between 18 and 30 months of age. Some researchers suggest that by 36 months, children have an abstract concept of negation that is used to convey a variety of communicative functions (Cameron-Faulkner, Lieven, & Theakston, 2007; McNeill & McNeill, 1968; Pea, 1978).

Fourth, previous studies have almost exclusively focused on children's production of negation. A tacit assumption is that children's linguistic production provides a straightforward window into their conceptual development. However, children's linguistic comprehension may differ substantially from their production, and these in turn may differ from their conceptual representations. . . . Therefore, developmental patterns

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