Separating Cognitive Development from Language Development in the Acquisition of Negation using International Adoption

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Anonymized data and code for reproducing all analyses are available at osf.io/sqehw

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Abstract:

Children learning words face at least one challenge, maybe two. First, children must gather enough information to identify which concept maps to which word (a **linguistic bottleneck)**. Second, for this mapping to be possible, children may need to acquire the concept itself if it is not already available to thought (a **conceptual bottleneck)**. We investigate whether children face one or both challenges when learning the English words for negation, a concept that is abstract and non-referential, yet universal across human thought and languages. We tested whether a linguistic bottleneck is sufficient to explain how children learn to express negation by comparing negation production in typical English-learners and older internationally-adopted preschoolers, who are more conceptually mature but face a similar language-learning task. If infants normally face a conceptual bottleneck, older adoptees, who do not, should learn negation faster. If the only bottleneck is linguistic, the two groups should learn negation at the same rate relative to their acquisition of English. In Study 1, parent reports on the CDI showed that older international adoptees and language-matched infant first-language learners begin producing *no* and *not* at the same point in vocabulary growth. Study 2 examined children's production of logical denial uses of negation words in longitudinal corpora of parent-child interactions. Adopted preschoolers' and language-matched infants' production of denials increased at the same rate relative to the mean length of children's utterances. Matching patterns of negation acquisition in internationally-adopted preschoolers and first-language-learning infants support a solely linguistic, not conceptual, bottleneck on learning negation words.

Public Significance Statement:

Children face two possible challenges when learning word meanings: they need to learn which words express which concepts, and, in some cases, they may need to learn the concepts themselves. Using negation ("no," "not") as a case study, we tested whether how hard it is for children to learn reflects a conceptual bottleneck (learning the concept of negation) or a linguistic bottleneck (learning how English expresses it). We compared infants learning English from birth with older internationally adopted preschoolers, who are more cognitively mature but otherwise have to learn English similarly to how first-language learners do. We found that older adoptees' greater conceptual maturity did not give them an advantage in learning negation: both groups began using "no" and "not" to mean logical negation at similar points in language development. These results suggest that children's early challenge is primarily about learning which word expresses negation, not the underlying logical concept.

Keywords: negation, word learning, language acquisition, international adoption, conceptual development

With just one word—*no* or *not*—speakers of English can express the abstract concept of negation. With *no*, they can deny the truth of anything previously asserted or give a negative answer to a question. With *not*, they can modify any expression to mean its opposite. Being experts at this, adult speakers may not realize that it is an achievement for children. Although *no* is one of the first words many English-speaking children say (Fenson et al., 2007; Frank et al., 2016), they do not initially use it to negate as abstractly or broadly as adults do. Instead, starting around 12-15 months of age, children use *no* primarily as a holophrastic command—specifically to reject offers, requests, and other parental affronts to their autonomy (Bloom, 1970; Choi, 1988; Nordmeyer & Frank, 2018; Pea, 1980; *cf.* Liu & Jasbi, 2025). By 18 months, children also begin to produce *no* in two-word utterances. Most of these utterances have a different function: remarking on the absence or nonexistence of something they wanted or expected, as when a child runs out of juice in their cup and says, “no more” or “no juice”.

The fact that children’s early uses of *no* are limited to particular communicative contexts could indicate that when children first say *no*, they take its meaning to be narrower than logical negation (Pea, 1980). Indeed, it is not until after their second birthday that most children begin to use the word *no* to deny the truth of assertions or give negative answers to questions in a way that more transparently denotes logical, truth-functional negation (Bloom, 1970; Choi, 1988; Nordmeyer & Frank, 2018; Pea, 1980). In addition to *no*, around this same age, English-speaking children also begin to produce other forms of negation, including *not* and *don’t* (Fenson et al., 2007; Frank et al., 2016). Most significantly, they begin to comprehend truth-functional uses of both *no* and *not*. At 20 months, children understand that the word *not* – at least when coupled with negative prosody, frowns, and headshakes – blocks the application of a nominal label (as in “This is not a danu.”; De Carvalho & Dautriche, 2025). Starting around 24-27 months of age, children playing a hide-and-seek game with a toy can interpret clues like "the ball is not in the bucket", correctly searching in an alternate container (Austin et al., 2014; Feiman et al., 2017; Grigoroglou et al., 2019). Thirty-month-olds similarly comprehend the truth-functional meaning of *didn't* as expressing the opposite of *did* (Reuter et al., 2018). This cluster of linguistic negation abilities emerges around the second birthday, suggesting that children learning English have learned the mappings between the concept of truth-functional negation and its various linguistic expressions by that age.

What explains the delay—nearly a full year on average—between children's earliest production of *no* shortly after their first birthday, and the multiple simultaneous milestones that mark their production and comprehension of truth-functional *no* and *not* shortly after their second?

To learn the meaning of any word is to solve at least one task, and maybe two: to learn the mapping between the word form and its meaning, and—if the concept that underlies that meaning is not already available to thought—to acquire the concept. The first task must be solved in each instance of word-learning. Children are not born knowing the meanings of the particular words in their language, so for every word that they learn, children must use the information available to them to resolve the mapping between that word-form and its meaning. This is in itself a very hard problem (Quine, 1960), and can take children many years (Gillette et al., 1999; Gleitman, 1990), especially where the input is frequently consistent with multiple candidate meanings (Illingworth et al., 2025). However, for some words, children may not even start out with the capacity to think about the meanings expressed. That is, they not only need to learn the mapping between the word and the concept it expresses, but they must acquire the concept itself (e.g., Carey, 2009; 2010). These two processes may happen in sequence or in parallel; exposure to a particular word may be necessary for a child to acquire the relevant concept. But regardless, by the time a child has successfully learned a mapping between a word and its meaning, they must also have access to the concept that underlies that meaning. That is, by the time the language-learning task is done, the concept-learning task, if there was one, must also be concluded.

Thus, as with any word, there are two possible limiting factors in the acquisition of negation (see Feiman et al., 2017). Children learning negation words may face a **conceptual bottleneck**: they may need to acquire the concept of negation itself before they have any chance of learning its mapping to the negation words of their language (Gopnik, 1984; Pea, 1980). Or children learning these words might already have access to the concept of negation, and so instead face only a **linguistic bottleneck**: they may merely need to solve the task of learning which words in their language express negation (Gomes et al., 2023). It is difficult to test which of these factors is the primary limit on children's acquisition of negation under normal circumstances, because typically developing children make gains in both linguistic and conceptual development in tandem as they grow (see Snedeker & Gleitman, 2004). To disentangle the separate contributions of language knowledge and conceptual development in the acquisition of verbal negation, we turn to a natural experiment that pulls these variables apart: children who have been internationally-adopted into a new language environment during the preschool years (Snedeker, Geren, & Shafto, 2007; 2012).

In the remainder of this introduction, we review in more detail the evidence on how children begin to produce and understand logical negation across languages. We then take the conceptual and linguistic bottlenecks in turn, discussing how each might arise. Finally, we argue that internationally-adopted preschoolers offer a uniquely strong natural experiment to distinguish between these two hypotheses.

Production and Comprehension of Logical Negation Across Languages

Though most of the research on the production of negation has studied English-speaking children, evidence from other languages suggests that the pattern observed in English, in which early uses of negation are limited to particular communicative functions like rejection and comments on absence, is quite robust. Analyses of children's productions reveal that the earliest negations express rejection, prohibition, or nonexistence in French, Korean (Choi, 1988), Japanese (McNeill & McNeill, 1968), Tamil (Vaidyanathan, 1991), and Cantonese (Tam & Stokes, 2001). In all of these languages, expressions of logical negation were rare or absent in the youngest children's speech and emerged gradually. In a large-scale corpus analysis of negative productions in 5 languages (Çabuk-Balli et al., 2025), rejection predominated among early negations in Chintang and Indonesian; the remaining three languages—English, Sesotho, and Turkish—already showed significant use of logical negation in the earliest transcripts, but the youngest children in that study were already 24 months old, and so may have already passed any rejection-only stage.

In addition to the limited contexts in which young children produce negation, there are several other reasons to believe that children might initially interpret negation words as having meanings narrower than logical negation. First, in English, adults use *no* to deny the truth of prior statements much more frequently than young children do (Bloom, 1970; Cameron-Faulkner et al., 2007; Gomes et al., 2023), suggesting that children's more limited usage of *no* is neither a reflection of the input, nor inherent in how the word is generally used. Second, a number of languages from different language families have distinct lexical items for different functions, such as rejection and logical negation (e.g., Korean: Choi, 1988; Japanese: McNeill & McNeill, 1968 ; Tagalog: Schachter & Otanes, 1983; Tamil: Vaidyanathan, 1991). This suggests that these may be different concepts even for adults. Finally, consider that many of the contexts in which the word *no* is used to express logical negation are likely uninterpretable to young children, whether that is because they do not understand whatever was negated (as under the linguistic bottleneck account), or because they lack the concept of logical negation (as under the conceptual bottleneck account). Many of the contexts that remain, which children may then rely on to form their early hypotheses of the meaning of *no*, are consistent with a rejection interpretation. This is because *no* can express rejection as a one-word sentence without overtly composing with other linguistic material. Imagine that a child shoves their half-eaten cookie towards their parent's mouth. The parent could reject the slimy sweet by responding with "No!". Hearing such uses would give the youngest children good grounds for the narrow hypothesis that *no* just means rejection, even while they lack the linguistic or conceptual resources to learn the logical negation meaning of *no*.

All theories of how children learn to express negation must also account for cross-linguistic variation in the age at which the more abstract functions of negation appear. Though the earliest comprehension of logical negation in English has been reported between 20 and 27 months, Hungarian-speaking 18-month-olds demonstrate comprehension of both the nonexistence-specific negator, *nincsen*, and the logical negator, *nem* (Szabó & Kovács, 2025). At the same age, around 18 months, children learning French also appear to understand that the logical negator *ne…pas* blocks the application of a nominal label (De Carvalho et al., 2021).

These crosslinguistic differences indicate that there is some effect of the features of a particular language on children's ability to learn the meanings of negation words in that language. For instance, children learning English may be slightly delayed in figuring out the meanings of negation words because their form and position are tightly linked to the unusual English auxiliary system. A full understanding of English negation requires, among other things, mastering the syntactic contexts in which the auxiliary *do* has to be inserted into negative sentences, and understanding the prosodic (and pragmatic) contexts in which *not* is contracted to -*n't* (Klima & Bellugi, 1966; Tesan & Thornton, 2005; Thornton & Tesan, 2013). Nevertheless, despite this variation, a common pattern emerges cross-linguistically: the earliest negations children produce are confined to specific functional contexts, with both production and comprehension of logical negation lagging behind those initial uses.

A Possible Conceptual Bottleneck on Negation Acquisition

One possible explanation for children's protracted acquisition of negation is that they initially lack the ability to represent the abstract concept of negation itself, acquiring it only around the time that they produce and understand expressions of truth functional negation. This sort of conceptual bottleneck surely exists for many words that denote hard-won cultural knowledge and scientific concepts, such as *temperature, density,* and *genome* (see Carey, 1985; Carey, 2009). But there is also evidence that children must overcome a conceptual bottleneck for more common, less technical, and earlier acquired terms. For instance, children struggle to learn the meanings of words for periods of time (*minute*, *hour*, etc.), with competence emerging only after children have acquired the conceptual resources to understand the arithmetical relations between those concepts (Tillman & Barner, 2015). Similarly, children acquire the meanings of the first few natural numbers (*one, two, three, four*) very slowly and one by one, despite extensive exposure to these words in counting contexts (Carey, 2009; Le Corre & Carey, 2007).

Like the concepts of time and number, negation is a candidate for a concept that might be difficult for children to acquire. It is non-referential, applies content-independently, and is highly abstract in that it interacts directly with the truth-value of an utterance. A conceptual limitation could therefore take several different forms. Young children may just lack the specific ability to think about a negated proposition (Gopnik, 1984; McDermott-Hinman & Feiman, 2025; Pea, 1980). Or, more broadly, they may lack the ability to represent any function that operates directly on truth values, perhaps due to limitations on their capacity to represent either truth values themselves or propositions, per se. As several philosophers have argued (Burge, 2010; Davidson, 1975), propositional thought itself may be distinct from a simpler form of predicative thought tied to personal experience with the here-and-now; propositional thought as a whole may not emerge until around two years of age. Alternatively or additionally, there could be limitations on domain-general capacities like working memory or inhibitory control, which could be critical for composing negation with a proposition without getting the input and output proposition mixed up (Kaup et al., 2006; Nordmeyer & Frank, 2014).

While these are different alternatives, they are all types of **conceptual limitations**. They locate the source of children's difficulty with linguistic negation in their ability to represent, access, or deploy the logical meaning of negation words—the concept of truth-functional negation. Only after a child has overcome the relevant conceptual bottleneck would they have a chance to solve the further task of figuring out how the particular language they are learning expresses negation in its lexicon and morphosyntax.

One way to rule out a conceptual bottleneck would be if non-linguistic tests showed that children have the concept of negation before they learn the language for it. In fact, infants do succeed at some non-linguistic tasks that *could* involve negation before they are proficient with negation language. The trouble is that these tasks could also involve precursor representations that have only part of the function of negation. For instance, given the premise that either a snake or a ball is in a cup, on seeing that the snake is elsewhere (i.e., *not in the cup*), 12-month-olds infer that the ball is in the cup (Cesana-Arlotti et al., 2018). Similarly, given the premise that a ball is in one of two buckets, on seeing that the left bucket is empty (i.e., *the ball is not in the left bucket*), 18-month-olds look for the ball in the right bucket (Feiman, Mody & Carey, 2022). These tasks both require infants to contrast two things that cannot both be true—the snake cannot be both elsewhere and in the cup, and the left bucket cannot both be empty and contain the ball. This notion of two incompatible, or *contrary*, states of the world is certainly a component to understanding the full concept of logical negation: given a proposition *p*, *p* and *not p* cannot both be true. However, full logical negation has additional properties. For instance, negation obeys the Law of Excluded Middle: given a proposition *p*, either *p* or *not p* must be true (see Horn, 2001). There has not yet been proposed a non-verbal task that tests for an understanding of the Law of Excluded Middle (see McDermott-Hinman & Feiman, 2025 for further discussion).

Further, each of these tasks requires reasoning over a specific kind of information, for which specialized cognitive systems are independently known to exist—object tracking in Cesana-Arlotti et al. (2018) and visual search in Feiman et al. (2022)—and so we have no way of diagnosing the format of the representation. Infants may be succeeding at these tasks using representations that perform the function of negation but are encapsulated within a particular cognitive system, like the visual object tracking system. These representations would then be able to negate only the sort of content present in that cognitive system (e.g. properties of visual object files), in contrast to the capacity of a negation concept to negate any proposition whatsoever (see Feiman, Mody & Carey, 2022 for further discussion). Therefore, as things stand, our best method for diagnosing full-functioned and domain-general negation is competence with the language used to express it. This returns us to the question at hand: is children's difficulty with negative language due to their difficulty with the concept of negation, or merely with the language itself?

A Possible Linguistic Bottleneck on Negation Acquisition

Regardless of whether the concept of negation is initially available to them, any child learning a language must eventually figure out which of the many words they hear express negation. This task in itself poses serious challenges. Children learning language are presented with continuous speech produced in widely varying contexts and must somehow extract from that input the meanings of words. Even for something as simple as a common concrete noun, this is a difficult task—nouns don't always co-occur with their referent, and even when they do, they might reasonably correspond to it under an infinite number of descriptions (Quine, 1960). With words whose referents are relations as opposed to objects, these problems multiply. To learn the meanings of transitive verbs, for example, children need to have acquired some knowledge about the syntax of their language (to identify who did what to whom when a transitive verb is used), as well as the meanings of at least some concrete nouns (to identify which noun is the who and which is the whom; see Gillette et al., 1999; Gleitman, 1990).

Now consider the even more abstract category of negation. Negation does not reliably co-occur with any particular perceptual feature of the child's environment (see Gomes et al. 2023). Linguistic expressions of logical negation generate identifiable meanings only compositionally, reversing the truth values of otherwise well-formed sentences. Therefore, a learner may not be able to figure out that words such as *no* and *not* express negation until they first understand the meanings of the sentences being negated. Imagine how hard it would be to figure out what *not* means in the book title, "Hands are not for hitting," (Agassi & Heinlen, 2002) if one does not understand the meaning of the corresponding affirmative, "Hands are for hitting" (see also Gomes et al., 2023). On this hypothesis, the child's challenge is not the concept of negation, but only a **linguistic bottleneck** on identifying which words express negation**,** which resolves as children learn more of their language.

There is no doubt that this challenge exists: children are not born knowing which words in their language mean negation, so they must learn the mapping between negation words and their meanings using the information available to them in their input. Is the difficulty of this task sufficient to explain children's slow acquisition of these words? Or are children additionally delayed by the need to learn to think using the concept of negation?

International Adoption as a Natural Experiment

To disentangle the separate contributions of linguistic knowledge and conceptual development in the acquisition of verbal negation, we turn to a natural experiment that pulls these variables apart: children who have been internationally adopted into a new language environment during the preschool years. These children are like young infants with respect to their knowledge of their adoptive language—they initially know no words and must gradually deduce their meanings. But their conceptual abilities are fairly similar to those of other preschoolers (Snedeker, Geren, & Shafto, 2007; 2012). If typical infant learners acquiring linguistic negation face a conceptual bottleneck, then we should expect more conceptually mature preschool adoptees to learn the language for negation earlier, relative to their overall language learning. However, if they face only a linguistic bottleneck, then preschool adoptees and infant first-language-learners should learn negation at the same point in language learning. In other words, comparing internationally-adopted preschoolers to typical infants learning English can test whether infants' challenge in acquiring negation is due only to the difficulty of the word-learning task or also to conceptual limitations.

The language learning problem faced by preschool-aged international adoptees can be characterized as "second first language acquisition" in several ways (De Geer, 1992). Unlike older second language learners, these preschoolers do not have access to written texts or bilingual informants. Like infants learning their first language, they are exposed to child-directed speech in an immersive home environment. They must learn the new language to communicate with their families, and they lack many of the metalinguistic skills that can aid language learning in school-aged children and adults (Gombert, 1992). Within a few months, they stop using their birth language and become effectively monolingual in their new language (Glennen & Masters, 2002; Snedeker et al., 2012).

The similar language-learning environments faced by infant learners and preschool-aged international adoptees results in a strikingly similar overall pattern of language acquisition. Preschool adoptees, like typical infants, first go through a one-word stage and then gradually begin producing longer utterances. The composition of their vocabulary likewise undergoes the same sequence of changes as monolingual infants. Early in acquisition, the majority of their productive vocabulary consists of words for social routines and a few common nouns, with the proportion of verbs and closed-class words rising later, as their vocabularies and the average lengths of their utterances grow (Snedeker et al., 2007; 2012). Because of the similarity of the language-learning environments of the two groups, if the limitation on learning verbal negation is a linguistic bottleneck, then we should expect negation to emerge at a similar point in the overall trajectory of language acquisition in both groups.

At the same time, the relative conceptual and cognitive maturity of the older children shows: they make much faster gains in solving certain aspects of the language learning problem than typical infants. They learn new words at a much faster rate than either younger internationally-adopted infants (Snedeker et al., 2012) or infants learning their first language (Snedeker et al., 2007; Krakow et al., 2005; Nickel et al., 2013; Pollock, 2005). Most relevant to the acquisition of negation words, they learn certain abstract words earlier in the course of language acquisition compared to children who were adopted in infancy (Snedeker et al. 2012). Specifically, they are quicker to learn time words that refer to events in the past and the future (*later*, *tomorrow*, *yesterday*), but not those that refer to the present (*now*). They are also quicker to learn adjectives that describe internal states (e.g. *hungry*, *scared*) and ones that are used in behavioral directives (*be careful*), but not adjectives with more easily observable perceptual correlates, like color words. The cognitive advantages of older children thus appear to allow them to learn at least some abstract words earlier relative to their overall acquisition of their adoptive language. Therefore, if learning verbal negation is limited by a conceptual bottleneck, then we should expect preschool adoptees to learn negation earlier in the overall course of language learning than infant learners do.

However, the natural experiment of international adoption makes the latter data pattern harder to interpret than the former. In addition to the greater cognitive maturity granted by an additional two years of life, it is likely that the internationally-adopted preschoolers studied by Snedeker et al. (2007; 2012) had already learned the words for negation in their birth languages. The adoptees in those studies were primarily from Russia and China, and prior research on the acquisition of verbal negation in Russian (Protassova, 1997; Snyder & Bar-Shalom, 1998) and Mandarin (Zhou, Crain, & Thornton, 2014a; 2014b), suggest that Russian and Chinese children typically learn the words for logical negation well before preschool (in line with cross-linguistic patterns more broadly; see Dimroth, 2010). Thus, preschool-aged adoptees learning English are not only more conceptually mature, they likely also already know negation words in their birth languages. It is possible that having mapped negation to words once makes it easier to do again, even relative to the much faster rate of adoptees' word learning. In the case of Russian in particular, maybe learning that the adverb *не* (pronounced [nʲe]) expresses negation in Russian makes it easier to subsequently figure out that a phonologically similar English adverb (*not)* does the same. Therefore, if we find that adoptees do learn negation words earlier in the course of language acquisition than first-language-learners, that difference could be attributed to the effect of prior language learning and not necessarily to a purely conceptual advantage. However, if we find that adoptees and first-language-learners learn negation at the same point in their language acquisition process, then we can rule out even this possible facilitation of prior language learning and conclude that the bottleneck on both groups of learners is specific to the language in which they are learning the negation word. This would be consistent with children needing to acquire enough linguistic information to understand the corresponding affirmatives in order to infer which words express negation.

To test whether internationally-adopted preschoolers learn truth-functional negation faster than typical infants, we matched the two groups on a measure of overall language acquisition and then compared their acquisition of linguistic negation using two measures of competence. First, in Study 1 we examined when children in each group begin to produce the English words for negation (*no* and *not*), relative to the size of their productive vocabularies. This comparison can tell us whether adoptees and typical infants begin to say negation words at the same point in language acquisition. However, it leaves open the possibility that the different groups use these words to express different meanings. Therefore, in Study 2 we examined more closely what adoptees and typical infants mean when they first start using negation words by comparing when children in each group start to use these words to express the truth-functional meaning of negation.

Transparency and Openness

We report all data exclusions and manipulations. Anonymized data and code for reproducing all analyses are available via the Open Science Framework (McDermott-Hinman et al., 2026)[1]. We did not preregister the design and analyses of these studies. Data were analyzed using R, version 4.4.1 (R Core Team, 2024), and the package lme4 (Bates et al., 2015).

Study 1

To determine whether international adoptees learn negation words at the same point in language acquisition as typical infants, we first compare the emergence of the words *no* and *not* in the expressive vocabularies of each of three groups of children: internationally-adopted preschoolers, and two control groups—US-born infants and internationally-adopted infants. International adoptees are drawn from a different population than children raised in their birth country, and there may be group-level differences in a variety of factors specific to the causes and experience of international adoption. The adopted infants, like the older adopted children, have experienced international adoption, but like the US-born infants, they are acquiring English as a first language in infancy, and thus they have the same cognitive limitations as any other toddler (Snedeker et al., 2012).

Methods

Participants

[1] The utterances themselves (in Study 2), as well as children's birthdays, were redacted from the data, as they rendered families too easy to identify in such a small population.

Three groups of children were included in the analysis, drawn from data collected for previous studies of language acquisition in internationally-adopted children (Snedeker et al., 2007, 2012). The group of older adoptees consisted of 75 children adopted to the US from China and Eastern Europe. The two other groups were controls: 68 US-born monolingual first-language-learning infants, and 24 children adopted from China as infants.

Parents were mailed the materials to fill out the MacArthur-Bates Communicative Development Inventory 2 long form (CDI-2; Fenson et al., 2007). The CDI-2 long form consists of a 680-item parent-report vocabulary checklist, as well as several measures of sentence complexity. The CDI-2 is normed for use in children 16 to 30 months of age, but it has also been used as a measure of language development in older, atypically developing children (Singer Harris et al., 1997; Thal et al., 1999), and has been found to be a sensitive index of early English language acquisition in adopted preschoolers (Snedeker et al., 2007; 2012).

We took the estimated size of children's productive vocabularies, calculated by summing over the words that parents reported that their children said, as a measure of their overall language development. Vocabulary size has been found to be highly correlated with other measures of language development, including sentence complexity, the mean number of words per utterance in a sample of production, and the number of different word types in a sample of production in both internationally-adopted infants and preschoolers, with no differences found between the two groups in any of these effects (Fenson et al., 1994; Snedeker et al., 2012).

Our dataset was a subset of data collected by Snedeker et al. (2007) and Snedeker et al. (2012). Datapoints were selected such that the distribution of vocabulary sizes was closely matched between the internationally-adopted children and both infant groups (Table 1). After matching, 4 US-born infants and 26 internationally-adopted preschoolers contributed two datapoints each to the study, and all other participants contributed one datapoint each, for a total of 101 datapoints for adopted preschoolers (53 from China, 47 from Eastern Europe, and 1 from Korea), 24 datapoints for adopted infants (all from China), and 72 datapoints for US-born controls. The final dataset contained data from 75 adopted preschoolers who were between 2.1 and 5.8 years (M = 3.7) on arrival in the US, had been living in the US for between 0 and 1.5 years (*M* = 0.58), and were between 2.6 and 6.3 years old (*M* = 4.4); from 24 adopted infants who were between 0.7 and 1.3 years (M = 1.0) on arrival in the US, had been in the US between 0.3 and 1.7 years (*M* = 1.1), and were between 1.3 and 2.8 years old (*M* = 2.1); and from 68 US-born infants who were between 1.3 and 2.8 years old (*M* = 2.0).

Table 1

Descriptive Statistics for Vocabulary Size (CDI-2) in Children and Infants

	Internationally-Adopted Preschoolers	**Internationally-Adopted Infants**	**US-born Infants**
Mean	362	390	360
Standard Deviation	183	191	182
Median	386	458	388
Minimum	14	35	23
Maximum	679	638	673

Results

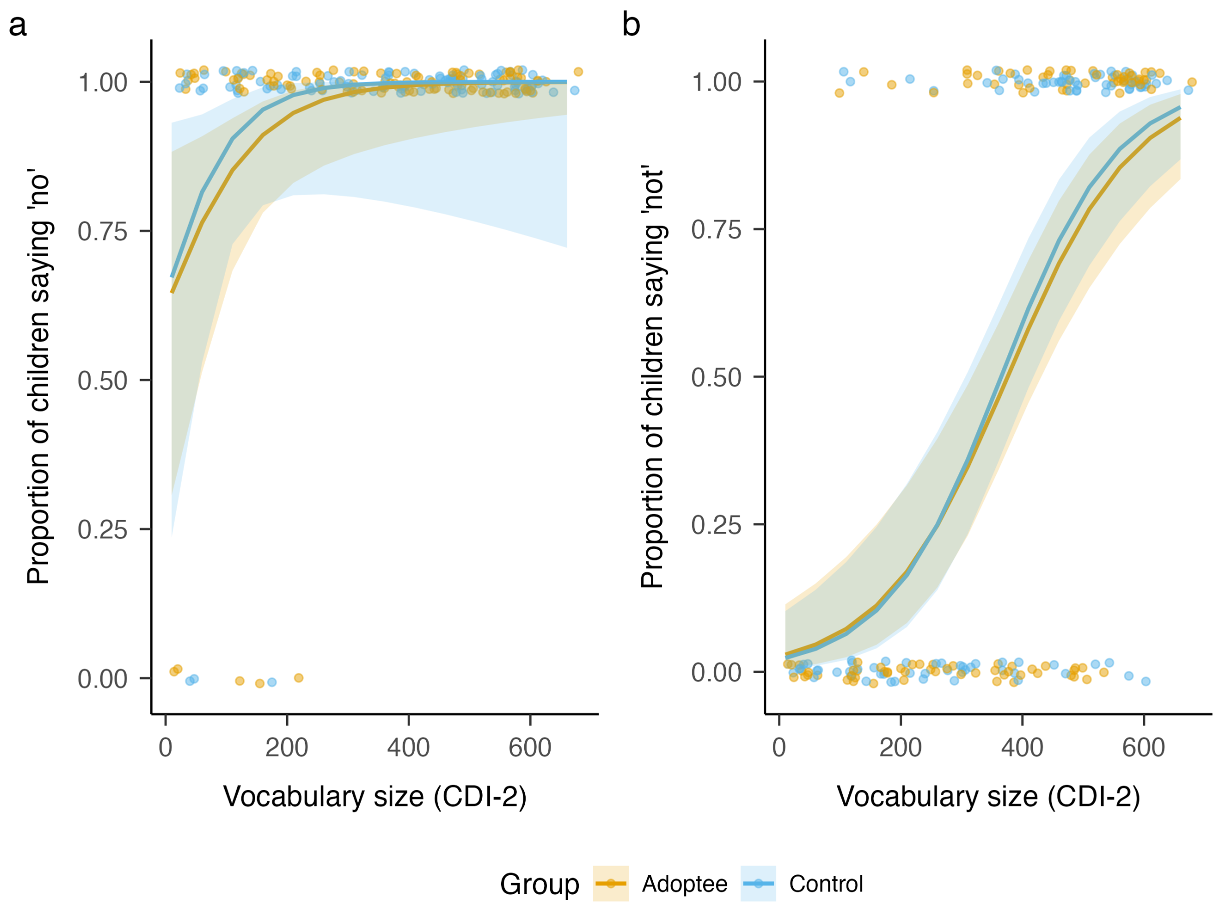
Figure 1 shows the distribution of children saying *no* and *not* in each group as a function of their vocabulary size. As expected, children began producing *no* very early in vocabulary acquisition: even among children producing less than 50 words, 69% were already producing *no*. In contrast, only at vocabulary sizes around 400 words were 50% of children producing *not*.

We fit two separate fixed-effects logistic regression models to the data: one predicting whether a child says *no*, and one predicting whether a child says *not*. In each model, a child's vocabulary size, Group (preschool adoptee vs. infant) and, within infants, adoption status (US-born vs. internationally-adopted) were entered as predictors. Group and Adoption Status were coded using a Helmert contrast: the Group variable contrasted preschool adoptees with all infants, and the Adoption Status variable contrasted infant adoptees with US-born infants. We fit a model that included an interaction between vocabulary size and, separately, group and adoption status.[2] To test for main effects and interactions, we used log-likelihood chi-squared tests to compare logistic regression models with and without the relevant effect. To test for simple effects, we used Wald z-tests of the beta coefficients within the full model, including all fixed effects.

[2] In lme4 syntax, the model was specified as:
[says *no*/says *not*] ~ vocab_size * Group + vocab_size * adoption_status

Figure 1

Proportion of Children Reported to Say ‘No’ and ‘Not’ as a Function of Vocabulary Size



Note. Proportion of adoptees and control infants reported by their parents to say the word *no* (a) and *not* (b), as a function of their reported vocabulary size on the CDI-2 form. Each dot represents a data entry from one child, and regression lines shown are for fixed-effects logistic regression models with vocabulary size, Group, and their interaction as predictors.

Vocabulary Size was a significant predictor of children's reported production of both *no* ($\chi^2(1) = 20.15$, $p < .001$) and *not* ($\chi^2(1) = 94.81$, $p < .001$). There was no significant effect of Group in either model (no: $\chi^2(1) = 0.23$, $p = .632$; not: $\chi^2(1) = 0.003$, $p = .958$) and no interaction between Group and Vocabulary Size (no: $\chi^2(1) = 0.887$, $p = .346$; not: $\chi^2(1) = 0.205$, $p = .650$). There was also no effect of Adoption Status within infants (no: $\chi^2(1) = 0.134$, $p = .715$; not: $\chi^2(1) = 0.956$, $p = .328$), and no interaction between Adoption Status and Vocabulary Size (no: $\chi^2(1) = 0.968$, $p = .325$; not: $\chi^2(1) = 0.022$, $p = .883$)[3].

Post-hoc tests of each treatment-coded level of the Group variable revealed that the proportion of children producing *not* increased as a function of Vocabulary Size separately in each group (Preschool adoptees: $\beta = 0.010$, Z = 5.182, $p < .001$; Infants: $\beta = 0.011$, Z = 5.237, $p < .001$). The effect of Vocabulary Size on production of *no* was significant in Preschool adoptees ($\beta = 0.011$, Z = 2.376, $p = .018$), and marginal in Infants ($\beta = 0.015$, Z = 1.763, $p = .078$)

Discussion

In all groups of participants, children with larger vocabulary sizes were more likely to produce the words *no* and *not*. There was no difference between internationally-adopted preschoolers and infants in the proportion of children who were reported to say the words *no* and *not*, nor was there any difference between US-born infants and internationally-adopted infants. There was also no difference between any of those groups in the effect of vocabulary size on the probability of saying either *no* or *not*.

The children in our sample who were adopted internationally as preschoolers began the process of learning English after their second birthdays—some as late as after their fifth—and

[3] To ensure that some children contributing two datapoints did not impact the results, we repeated the model including only the first data point from each child and found an identical pattern of results. Because only a small number of children contributed two datapoints, a model with a random intercept for each participant did not converge.

thus faced the task of learning language with greater conceptual and intellectual maturity than typical infants. Nevertheless, they started producing the words *no* and *not* at the same point in vocabulary acquisition as children learning English as infants. This finding is consistent with the possibility that the primary bottleneck in learning negation words is not any difficulty with the concept of negation, but rather merely limited knowledge of the rest of the language. Even more mature preschoolers did not begin producing the word *not* until after they had already developed a sizable vocabulary of other words.

The word *no*, on the other hand, appeared very early in the vocabularies of both groups. This is consistent with the claim that children's early productions of *no* actually reflect more limited meanings like *rejection*, and not the logical concept of negation. However, just because older adoptees and infant controls begin to produce *no* and *not* at the same point in vocabulary growth does not necessarily mean that they begin to use those words to express logical negation at the same point. Study 2 will test this explicitly by examining how these words are used in children's early productions.

Study 2

Study 2 examined a longitudinal corpus of internationally-adopted children's natural productions, and a matched longitudinal corpus of US-born infants learning English. We performed a finer-grained analysis comparing the communicative functions of the negative utterances produced by both groups of children over the course of language development.

Methods

Participants

Eight adopted preschoolers' transcripts were taken from the longitudinal corpus developed by Snedeker, Geren, & Shafto (2012). All of the children were enrolled in their study within one month of arriving in the United States (age of arrival 2.4 - 5.5 years; M = 4.1; Table 2). Parents were asked to videotape themselves interacting with their child two times a month for 30–40 min and were given a standard set of toys to use while making the recordings. Each session was transcribed by a native English speaker. Parents made recordings approximately twice a month for 6 months, with further follow-up sessions 3 and 6 months later. Only families who recorded at least 12 speech samples spanning at least 9 months were included. Snedeker and colleagues had also excluded children if their parents used any language other than English with their child or if they were diagnosed with a major developmental disorder (e.g., autism spectrum disorders, Down syndrome, or intellectual developmental disorder), or any developmental disorder affecting speech production or perception (e.g., bilateral hearing loss, uncorrected cleft palate). Children reported to have developmental or language delays were not excluded, because that would risk excluding children who were learning English at a slower rate due to the change in language environment itself. One child originally included by Snedeker and colleagues was excluded in our study because they had already been in the US for more than 3 months at the time of their first session.

Measures

The mean length of utterance in words (MLU) for each session was derived from all child utterances from that session. MLU was chosen as an index of language acquisition because it applies across different ages and would allow matching of adopted and typical infants based on the longitudinal corpus data itself (see Snedeker et al., 2012). To increase the precision of MLU measures and decrease the effect of missing data when transcripts were not returned on schedule, transcripts from the same month were collapsed together into one session for the purpose of matching adopted children with controls.

Table 2

Participant Information

Participant pair	Language (Country)	Age on Arrival	Age at time of transcripts	# of Speech Samples	MLU Range	CHILDES Control	Control age at time of transcripts	Source Corpus for Control
A	Russian	2;5	2;7-3;8	15	1.04-2.56	Dominic	1;11-2;11	Manchester
B	Russian	5;0	5;2-6;7	13	1.09-3.49	Lily	1;9-3;2	Providence
C	Russian	5;6	5;7-6;7	15	1.20-2.90	Sarah	2;4-4;9	Brown
D	Russian	5;4	5;5-6;7	13	1.25-3.40	Joel	2;0-2;10	Manchester
E	Russian	4;2	4;3-5;5	14	1.39-2.74	Aran	2;1-2;11	Manchester
F	Russian	3;1	3;4-4;5	8 (12)*	1.55-2.42	Nina	2;0-3;1	Suppes
G	Mandarin (China)	4;3	4;3-5;5	12	1.93-3.61	Adam	2;4-5;2	Brown
H	Longyou (China)	2;9	2;10-3;11	13	1.36-2.61	Anne	1;11-2;2	Manchester

Note. All Russian-speaking participants were adopted from Russia. Adoptees' birth languages are listed as reported by their parents. *The last 4 speech samples from the adoptee in pair F were omitted by the second coder by mistake. They were coded by the first coder.

Matching

Each preschool adoptee was matched on the basis of MLU with a control infant for whom English was the birth language. Controls were drawn from the CHILDES database (MacWhinney, 2000), chosen based on the availability of transcripts from a single child that matched a given adoptee as closely as possible on MLU session-by-session. If more transcripts were available from the control, only those with the closest MLU match to the adoptee's sessions were used. The resulting range of the average MLU differences between an adoptee's sessions and the corresponding control transcripts within each matched pair was [-0.01, +0.04] and the average of the absolute values of differences per session did not exceed 0.09 for any matched pair. Controls were aged between 20.9 and 27.7 months (M = 24.4) at the time of their first transcripts.

Coding

All adoptee and control transcripts were given randomized numeric labels and were then coded by two native English speakers. Because some of the adoptees used words in their birth language, especially in the first few sessions after their arrival in the US, we decided to inform the coders that some of the children would be internationally-adopted from other countries, and that they may therefore encounter words in another language. Thus, the coders knew that there were two groups of children (US-born and internationally-adopted), but they did not know that the groups had different ages. Coders were not told which group a given transcript belonged to, nor were they aware of the hypotheses. Each coder identified utterances containing negation words by searching transcripts for any instances of a child saying: *no, not* (or its contraction -*n't)*, *nope*, *allgone*, and *gone*. Each utterance including any of these words was coded according to the scheme developed in Bloom (1970), using three categories: Rejection, Nonexistence, and Denial, reproduced here:[4]

REJECTION: Where the referent actually existed or was imminent within the contextual space of the speech event and was rejected or opposed by the child

NONEXISTENCE: Where the referent was not manifest in the context, where there was an expectation of its existence, and it was correspondingly negated in the

[4] The same coders also coded all the same utterances using the coding scheme developed by Choi (1988), which expands Bloom's scheme into 9 categories. However, like other recent studies (Nordmeyer & Frank, 2018; Liu & Jasbi, 2025) we found that most of the additional categories were low in frequency, so we do not report those results here.

linguistic expression

DENIAL: Where the negative utterance asserted that an actual (or supposed) predication was not the case

We were most interested in the category of Denial, as these were the cases in which a negator is most clearly used to express the logical concept of negation—asserting that a predication is not the case. The categories of Rejection and Nonexistence captured cases where negation was used in ways that might express logical negation, but could also express less abstract concepts, like a dislike of something ("No broccoli!") or an unexpected absence ("No more milk!").

Each coder classified each negation utterance into one of these categories and indicated with a binary flag whether they were certain about this classification. Following Bloom, the coder could also mark an utterance as Unclear if they felt that they could not classify the negation into any category. Utterances in which the child's negation was an exact repetition of an immediately preceding utterance, whether their own or another speaker's, were coded as Repetition and excluded (first coder's N = 370). For instance, if the child said, "no no no," only the first "no" was coded.

Data Processing. Because coders identified negations by manually searching through the transcripts, the two coders identified overlapping but not identical sets of negations. The first coder identified 4,602 negations, and the second coder identified 3,946 negations, with an overlapping set of 3,874 negations. The first coder's data included 200 negations from 4 transcripts that were mistakenly overlooked by the second coder. The results we report below are based on analyses of the first coder's data, as she coded more utterances. However, to assess the robustness of our findings to differences between coders, we compared the two coders where they coded the same utterances and also repeated all analyses using the second coder's data. The pattern of results was consistent in each case, unless otherwise noted.

The coders agreed on their classification for 78% of the negations they both coded (3,015/3,874 negations; Cohen's $\kappa = .58$). Reliability was highest for transcripts with MLU above 3 but there was meaningful agreement at all MLU levels (MLU 1-2: 76%, $\kappa = .57$; 2-3: 77%, $\kappa = .55$; 3+: 91%, $\kappa = .75$). This relatively modest reliability is consistent with prior studies (Nordmeyer & Frank, 2018) and reflects both the difficulty of interpreting the intended meanings of some utterances, as well as disagreements about how to apply Bloom's coding scheme. Coders agreed most often on Rejections (84% agreement), followed by Denial (78%) and Nonexistence (70%). Agreement was lowest on utterances marked Unclear (18%). Coders most often reported being certain in their Denial classifications (97% for coder 1; 92% for coder 2), followed by Rejection (96% for coder 1; 87% for coder 2) and Nonexistence (96% for coder 1; 83% for coder 2). The first coder's certainty on the classification of a given negation utterance was significantly correlated with agreement between the two coders on that utterance ($r = 0.21$, $t = 13.32$, $p < .001$). This pattern suggests that disagreements were most common in edge cases, while coders were more certain and more reliable on the Denials, which we are primarily interested in.

Results

We first analyzed Adoptees' and Controls' productions of each of the negative communicative functions in Bloom's coding scheme—Rejection, Nonexistence, and Denial—over the course of language acquisition. Then, to rule out a possible effect of the phonological similarity of Russian and English negation words, we repeated the analysis restricting the data to the Russian-speaking adoptees and their MLU-matched infant control. Finally, to identify any fine-grained differences between the groups, we broke down children's productions of Denial by the negator used to express it.

Production of Negative Communicative Functions

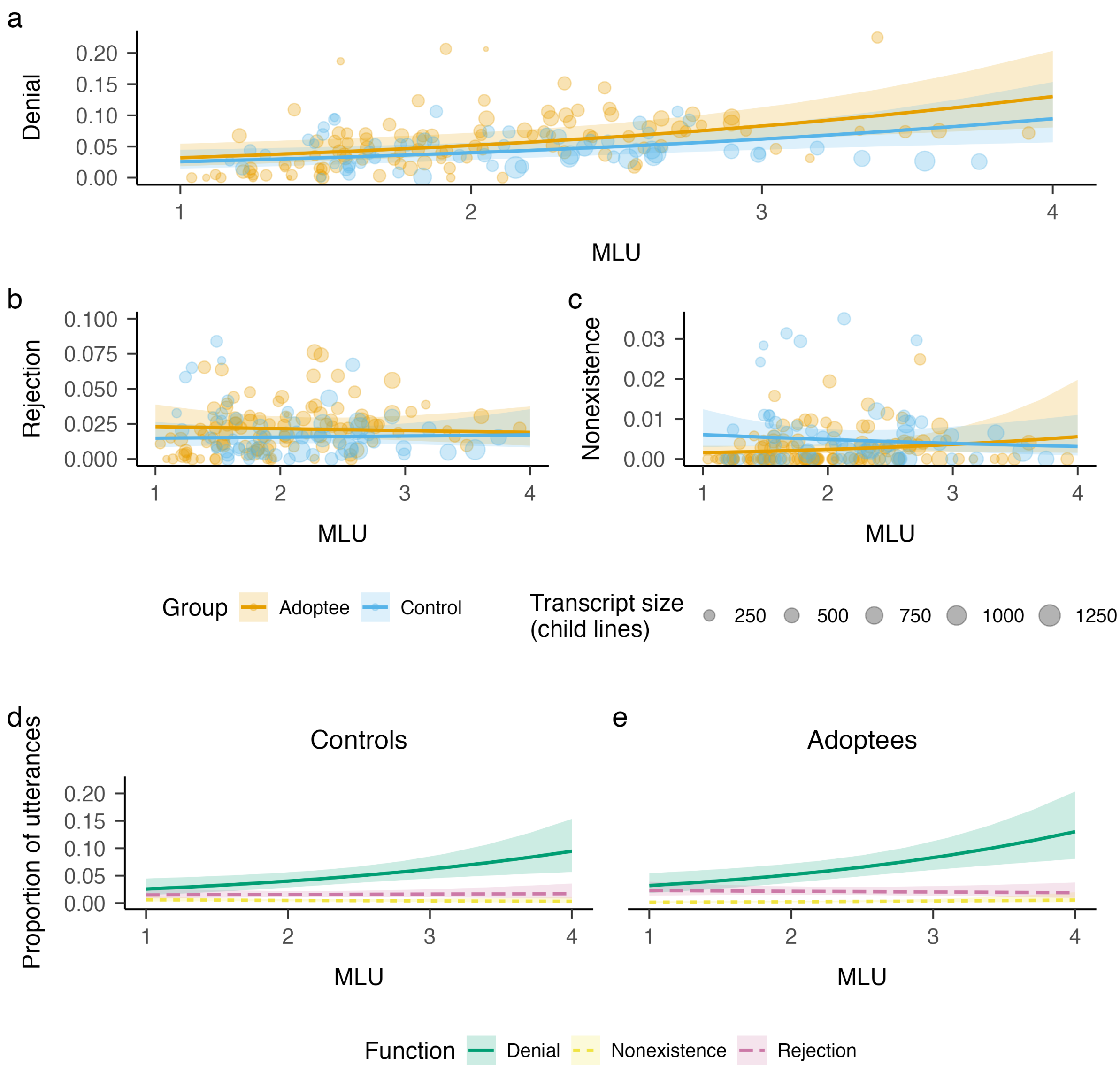
Figure 2 shows the proportion of utterances expressing Denial, Rejection, and Nonexistence negations as a function of MLU for internationally-adopted children and language-matched controls. We first fit three logistic mixed-effects regression models to separately predict the probability of a child producing each function of negation (Denial, Rejection, and Nonexistence). The data in the model consisted of all utterances by the child, and the binary DV in each case encoded whether the utterance contained a negation expressing, respectively, Denial, Rejection, or Nonexistence. Previous studies on negation production (e.g., Bloom, 1970; Nordmeyer & Frank, 2018) analyzed each function of negation as a proportion of all negations produced. This approach imposes an interdependence on the three functions – as the proportion of, e.g., Denials goes up, the relative proportion of other functions must go down – which does not reflect any natural constraint on children's production and may obscure developmental changes. Children could, over development, produce more (or less) of just one, or two, or all three negative functions. For this reason, we chose instead to model expressions of each function of negation as a proportion of all *utterances* produced (see also Liu & Jasbi, 2025). This allowed us to model the proportion of Denial utterances independently of the proportion of Rejection and Nonexistence utterances. At the same time, unlike a raw count of each function, this measure still accounts for the overall amount of speech a child produced.

Each model included the effect of Group (Adoptee or Control), MLU (continuous and grand-mean centered), and their interaction as fixed effects. Each model also included random intercepts by Subject, random slopes by MLU, and the correlation between them. This was both the maximal model consistent with the structure of the data, as recommended by Barr et al. (2013), and the model with the random effects structure that maximized model fit, as recommended by Matuschek et al. (2017).[5]

[5] In lme4 syntax, each model was specified as:
[Denial/Nonexistence/Rejection] ~ Group * MLU + (MLU | Subject)

Figure 2

Proportion of Negations by Function Across Mean Length of Utterance (MLU)



Note. The change in the production of (a) Denial, (b) Rejection[6], and (c) Nonexistence negations as a proportion of all utterances in a transcript as a function of MLU. Each filled dot represents a

[6] One transcript (Group=Adoptee, MLU=1.55, Proportion Denial=.35, Transcript Size=91) was removed from the Rejection plot for clarity, as including this outlier would have compressed the rest of the scale. It was not removed from the analyses, however.

speech sample, with size corresponding to the number of child utterances in that sample. Curves show predicted values derived from parameter estimates of the mixed-effects logistic regression models reported above, and error bars show 95% confidence intervals. (d) and (e) show the same curves organized by Group instead of Function.

There was a significant effect of MLU on the production of Denials ($\chi^2(1) = 18.91$, $p < .001$), with children producing more Denials at higher MLUs. Additionally, post-hoc tests of MLU at each treatment-coded level of the Group variable revealed that the proportion of Denials increased as a function of MLU separately in each group (Adoptees: $\beta = 0.50$, Z = 3.34, $p < .001$; Controls: $\beta = 0.46$, Z = 2.79, $p = .005$). Critically, however, we found no significant effect of Group ($\chi^2(1) = 1.74$, $p = .19$) and no interaction between Group and MLU ($\chi^2(1) = 0.04$, $p = .84$) on the proportion of utterances that included Denials.

There was no effect of MLU ($\chi^2(1) = 0.01$, $p = .92$), Group ($\chi^2(1) = 1.53$, $p = .22$), or their interaction ($\chi^2(1) = 0.20$, $p = 0.65$) on children's production of Rejection. There was also no main effect of MLU on productions of Nonexistence ($\chi^2(1) = 0.20$, $p = .66$), and no interaction between MLU and Group ($\chi^2(1) = 2.25$, $p = .13$). There was, however, a main effect of Group ($\chi^2(1) = 5.58$, $p = .018$): Controls produced more instances of Nonexistence as a proportion of their overall utterances than did Adoptees. However, this pattern was not replicated in the data from the second coder: Coder 2 showed no main effect of Group on productions of Nonexistence ($\chi^2(1) = 0.88$, $p = .35$) but did show a marginal interaction between Group and MLU ($\chi^2(1) = 3.20$, $p = .07$), with Adoptees' uses of Nonexistence increasing faster than Controls'.

Testing for First Language Interference

Age was not the only difference between infants and preschool adoptees. Adoptees had already begun to learn another language. It is therefore possible that some particular feature of the adoptees' birth language might have unduly influenced their acquisition of negation. In particular, the primary negators in Russian (*не* [nʲe], ни [nʲi], and *н*ет [nʲet]) have significant phonological similarities with the negators *no* and *not* in English. Six of the eight international adoptees included in this study spoke Russian as their birth language, so we did not have sufficient power to detect any effect of birth language. However, to ensure that the Russian-speaking adoptees did not show an advantage in learning negation that was washed out in the full sample, we repeated the above analysis restricting the dataset to the six Russian-speaking adoptees and their matched infant controls. The results were qualitatively the same as before. We once again found a significant main effect of MLU on productions of Denial ($\chi^2(1) = 12.68$, $p < .001$), but no main effect of Group ($\chi^2(1) = 0.79$, $p = .37$), and no interaction between Group and MLU ($\chi^2(1) = 0.03$, $p = .86$). For Rejection, there was no effect of Group ($\chi^2(1) = 0.84$, $p = .36$), MLU ($\chi^2(1) = 0.01$, $p = .91$), or their interaction ($\chi^2(1) = 0.53$, $p = .47$). Finally, for Nonexistence, as above, there was a main effect of Group ($\chi^2(1) = 6.07$, $p = .01$), but no main effect of MLU ($\chi^2(1) = 0.24$, $p = .63$) and no interaction between Group and MLU ($\chi^2(1) = 2.33$, $p = .13$). Strikingly, despite the significant phonological overlap with negators they had likely already learned, Russian-speaking international adoptees were just as slow as infant learners to learn the Denial meanings of the words *no* and *not*.

Controlling for Utterance Length and Parents' Speech

We chose to use the mean length of utterances in a transcript as a predictor because it provides a metric of language development that is independent of age. However, it is also possible that the length of an utterance itself predicts an utterance being coded as a Denial—

perhaps it's easier for a child to express a Denial, or easier for a coder to tell that a Denial has been expressed, in a longer utterance (e.g., "That's not a lion!") than in a one- or two-word utterance (e.g., "No lion!"). Because transcripts with smaller MLUs will, by definition, have more short utterances, any relationship between utterance length and Denials could confound our use of MLU as a measure of language learning. To account for this possibility, we fit an additional mixed-effects logistic regression model with whether an utterance expresses Denial as the DV, and Group, MLU, and the Utterance Length (in words) as factors, as well as all two- and three-way interactions. We found that even after controlling for the Utterance Length, there was a significant main effect of MLU ($\chi^2(1) = 12.71$, $p < .001$), but no main effect of Group ($\chi^2(1) = 1.79$, $p = .18$), and no interaction between Group and MLU ($\chi^2(1) = 0.33$, $p = .57$). The interaction between MLU and Utterance Length was also not significant ($\chi^2(1) = 0.48$, $p = .49$). Though it was not the primary target of this analysis, we did find a main effect of Utterance Length and an interaction between Utterance Length and Group (while Adoptees produced more Denials in longer utterances, Controls did not). See Appendix A for those results and further discussion.

Another way in which the two groups might differ that could confound our analysis is in how their parents spoke to them. Parents of adoptees might speak to them differently for any number of reasons—their children were older than typically developing children at the same point in language learning, they had just been through a rigorous adoption vetting process, they were less familiar with their children than parents of typically developing children, and they were provided with the same set of toys to use at each session, while the transcripts of the typically developing children in this study were from a wide variety of contexts. To control for possible differences in parents' speech, we fit an additional mixed-effects logistic regression model predicting children's productions of Denials, including factors for Group, MLU, and two measures of parents' speech: parents' overall MLU, and the proportion of their utterances that contained the word *not*. Because coding children's negations according to Bloom's scheme took several people several years, we did not repeat the same coding for parents' negations. Instead, we used parents' production of the word *not* as a proxy for their use of logical negation, as prior work had found that *not* is most frequently used to express Denial in parents' speech to their children (Gomes et al., 2023).

Children produced more Denials when their parents' speech had a higher MLU ($\chi^2(1)$ = 19.06, $p < .001$) and when parents said *not* more often ($\chi^2(1)$ = 13.01, $p < .001$). However, even controlling for these effects, children with higher MLUs still produced more Denials ($\chi^2(1)$ = 7.58, $p = .006$). Critically, as in our original analyses, there was no effect of Group ($\chi^2(1)$ = 1.53, $p = .22$), and no interaction between Group and MLU ($\chi^2(1)$ = 0.84, $p = .36$) when controlling for the parent's MLU and production of *not*.

Production of Denial by Negator

To test whether there are differences between the two groups' uses of *no* and *not* separately to express Denial, we fitted two additional models predicting the proportion of children's utterances expressing Denial using, respectively, *not* (including the contraction *-n't*), and *no* (including *nope* which can, like *no*, be used as a response particle to deny a previous utterance). As a conceptual replication of Study 1, we additionally fit two models predicting the proportion of children's utterances containing *no* and *not*, regardless of meaning category. All models included MLU, Group, and their interaction as predictors, with a maximal random effect structure including random intercepts by Subject, random slopes by MLU, and their correlation.

The other negators we coded (*allgone* and *gone*) occurred with too low an incidence to be assessed in this analysis (N = 52) and expressed only Nonexistence.

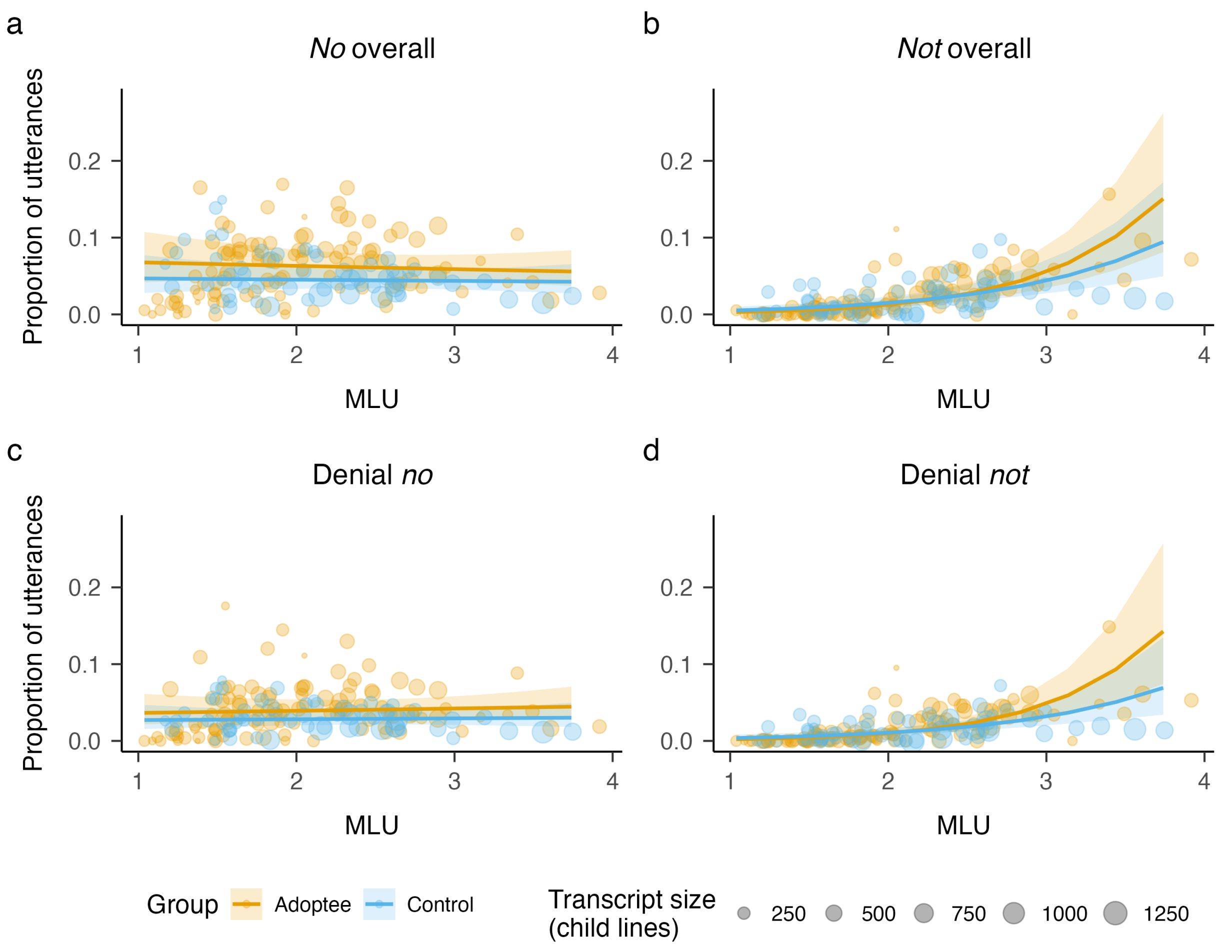
Figure 3 shows the proportion of utterances containing *no* and *not* overall, as well as expressions of Denial using *no* and *not* across MLUs for Adoptees and Controls. In line with Study 1, there was a significant effect of MLU in predicting production of *not* ($\chi^2(1) = 85.61$, $p < .001$), but there was no effect of MLU in predicting production of *no* ($\chi^2(1) = 0.30$, $p = .59$). There was a marginal effect of Group on the production of *no* ($\chi^2(1) = 2.91$, $p = .09$), but no effect of Group on the production of *not* ($\chi^2(1) = 0.01$, $p = .94$), and there was no interaction between Group and MLU in either case (*no*: $\chi^2(1) = 0.03$, $p = .86$; *not*: $\chi^2(1) = 1.95$, $p = .16$)

There was also a significant effect of MLU in predicting production of Denial *not*, with more expressions of Denial *not* at higher MLUs ($\chi^2(1) = 57.44$, $p < .001$), but no effect of Group ($\chi^2(1) = 0.35$, $p = .55$), and no interaction between MLU and Group ($\chi^2(1) = 2.00$, $p = .16$). Model-predicted Denial *not* was rare (less than 1%) at the lowest MLUs—2.1 per thousand of the Adoptees' utterances (95 % CI [1.0, 4.7]) and 3.7 per thousand of the Controls' utterances (95 % CI [1.7, 8.3]) for children with an MLU of 1.04 (the lowest in our study). Overall, Denials constituted 79.6% of Adoptees' uses of *not*, and 76.5% of Controls' uses. *Not* predominantly expressed Denial even at the lowest MLUs: in children with MLUs between 1 and 2, Denials constituted 91.3% of Adoptees' uses of *not*, and 80.1% of Controls' uses.

For Denial *no*, there was no effect of MLU ($\chi^2(1) = 0.26$, $p = .61$) but a marginally significant effect of Group ($\chi^2(1) = 2.82$, $p = .09$). However, the effect of Group was not significant in Coder 2's coding ($\chi^2(1) = 1.43$, $p = .23$). More critically, and consistently across both coders, there was no interaction between Group and MLU in predicting Denial *no* ($\chi^2(1) = 0.02$, $p = .88$). Children even with the lowest MLUs already produced tokens of Denial *no*—for children with an MLU of 1.04 (the lowest in our study), model-predicted Denial *no* comprised 36.6 per thousand of Adoptees' utterances (95 % CI [21.6, 61.2]) and 27.2 per thousand of Controls' utterances (95 % CI [15.6, 46.8]). Although a smaller proportion than Denial uses of *not*, Denials were still the majority of *no* utterances, and constituted 63.5% of Adoptees' and 61.5% of Controls' uses of *no* overall, across all MLUs.

Figure 3

Proportion of 'No' and 'Not' Utterances, Overall and Expressing Denial, Across MLU



Note. (Top) Proportion of children's utterances containing (a) *no*[7] and (b) *not*, as a function of children's MLU. (Bottom) Proportion of children's utterances expressing Denial negation using (A) *no* and (B) *not*, as a function of children's MLU[8]. Each dot represents a transcript, and curves show predicted values derived from parameter estimates of the mixed-effects logistic regression models specified above. Error bars on both plots show 95% confidence intervals. (Bottom)

[7] One transcript (Group=Adoptee, MLU=1.55, Proportion *No*=.52, Transcript Size=91) was removed from the '*No* overall' plot for clarity, as including this outlier would have compressed the rest of the scale. It was not removed from the analyses, however.

[8] Though there was not a significant interaction between MLU and Group in predicting Denial 'not', there is the slight appearance of one on this graph. This appearance is likely due to the upward-sloping shape required by a logistic curve, and seems to be driven by a small number of transcripts from the 6 children (3 Adoptees and 3 Controls) whose MLU reached above 3. Crucially, even just this apparent difference is only present at the highest MLUs. The conceptual bottleneck hypothesis would predict a difference between Adoptees and Controls in the early stages on language acquisition, not the later stages.

Discussion

We found that both internationally-adopted preschoolers and younger native English-learning infants produced more Denial uses of negation words as they learned more language, with no differences between these groups in the rate of that change or in the overall proportion of Denials produced. This finding persisted when controlling for the length of children's utterances, and when controlling for parents' use of *not* and the overall length of parents' utterances. Being an older, more cognitively sophisticated learner does not appear to have appreciably speeded the rate at which children start to produce logical uses of negation.

General Discussion

Our findings suggest that infants' slow acquisition of the English expressions of negation can be entirely accounted for by their limited early knowledge of the rest of the English language itself, without the need to appeal to the availability of the concept of negation. In Study 1, we found that internationally-adopted preschoolers and typical infants begin to say the words *no* and *not* at the same point in their overall vocabulary growth. In Study 2, we found that the trajectory of the emerging expression of logical denial was identical, relative to overall language learning, for international adoptees and typical infants.

When we see patterns of late denial negation in typically situated infants, they are often attributed to the gradual acquisition of the concept of negation (Bloom, 1970; Pea, 1980). In the case of the adopted preschoolers, we know they cannot be missing that concept. Not only are they at an age when children typically understand negation words already, we have good reason to believe that they have already acquired these words in their birth languages. Based on prior research on the acquisition of verbal negation in Russian (Protassova, 1997; Snyder & Bar-Shalom, 1998) and Mandarin (Zhou, Crain, & Thornton, 2014a; 2014b), as well as broader cross-linguistic patterns (see Dimroth, 2010), it is very likely that by the time these children were adopted, they had already learned to express truth-functional negation in their birth language. Indeed, we even found that one of the adopted children in Study 2 repeatedly used a morphologically complex form of Mandarin negation (*bùyào*, meaning literally 'not want') when speaking to their adoptive parents in their first few weeks after arrival in the US. If this child, and other preschoolers, had already learned to express negation in their birth language, then they not only possessed the requisite concepts for, they also probably had access to translation equivalents of the English words *no* and *not* in their birth language.

This means that there is no need to appeal to conceptual or other cognitive limitations in accounting for the slow acquisition of denial negation in typically developing infants—linguistic limitations are sufficient to generate this same trajectory in older children who do not face any conceptual bottlenecks. Children of all ages face a common challenge – figuring out which words express the concept of negation, given a limited understanding of the language they hear.

In the remainder of this discussion, we will first discuss the primary effect that we found—an increase in the production of denial negations as MLU increased. We will consider the difference in this effect across negators and explore why there was no effect of MLU on rejection and nonexistence uses of negation. We will then consider what the linguistic bottleneck on learning negation might consist of, and what we can (and cannot) conclude from this work about the concept of negation, as compared to other abstract, non-referential concepts.

Increase in the Production of Denial over the Course of Language Learning

Consistent with a linguistic information bottleneck, the primary effect we found was that all children—no matter their age—produced more denial negations as they learned the language, as measured by the mean length of their utterances (MLU). This effect remained when controlling for the length of a particular utterance, which suggests that it was not a mere artifact of denials being either easier for coders to code or easier for children to express in longer utterances. The effect of MLU on denials also remained when controlling for the mean length of parents' utterances in a transcript, and for parents' rate of using the word *not* (serving as a proxy for parents' expressions of denial). This rules out the possibility that some true difference between the groups had been obscured or cancelled out by differences in the way parents in the two groups spoke to their children.

Differences Between Negators in the Effect of Language Learning

However, the effect of MLU was not consistent across negators. We found a large effect of MLU on production of denial *not*, but little to no effect of MLU on production of denial *no*. In fact, *no* was already being used to express denial at the earliest MLUs present in this dataset, while denial *not* (and *not* at all) was almost unattested in the same MLU range.

At first glance, the early emergence of denial *no* compared to denial *not* seems inconsistent with prior studies of comprehension. Prior work has found that children begin to understand both *no* and *not*, used to express denial, at the same age in English, either at 24 months (Austin et al., 2014), or 27 months (Feiman et al., 2017). It was this common age of comprehension that prompted the hypothesis that there exists a 'bottleneck' in the acquisition of negation, either linguistic or conceptual (Feiman et al., 2017; see McDermott-Hinman & Feiman, 2025 for review).

However, the late overall onset of *not* used to express any function offers a possible resolution to this conflict: children may struggle to produce *not* for reasons unrelated to its meaning. *Not* in English is syntactically complex, interacting with the auxiliary system to produce contractions (*can't*, *don't*, etc.), and requiring do-support to compose with tense marking. Further, unlike *no*, *not* cannot stand alone as a complete sentence. It may be the case that long after they have learned the full logical denial meaning of the word *not*, children with short utterances and limited working memory still struggle to produce it (Tesan & Thornton, 2005).

Have children, then, already learned the denial meanings of both *no* and *not* by the beginning of our study? This is not implausible. Though the adopted preschoolers were enrolled within one month of arrival, they were already producing some English in their first transcripts. Language-matched controls were between 21 and 28 months (M = 24.5) at the start of the study, while the youngest *average* comprehension of both logical *no* and *not* in a group of English-learning children has been found at 24 months (Austin et al., 2014). If this timeline is correct, then it is reasonable to conclude that the children in our study had already learned the denial meanings of both *no* and *not* by the beginning of our study, and only struggled to produce *not* due to its additional syntactic complexity.

Alternatively, if the timeline suggested by Feiman et al. (2017) is correct, and children do not learn the logical meanings of *no* and *not* until 27 months, it may be the case that early uses of *no* that were coded as denials were actually not expressing denial at all, but rather a kind of metalinguistic rejection. That is, they could mean *don't say that* instead of *that is false* (Drozd, 1993; Drozd, 1995; Hummer et al., 1993). A rejection meaning, generalized to metalinguistic uses, may be just what children initially think *no* means, but is never a plausible meaning for the word *not*, as *not* cannot stand alone to reject—neither nonverbal or verbal offers or commands, nor the appropriateness of an utterance. Indeed, Drozd (1995) previously argued for exactly this possibility, finding that early denial uses of *no* tended to accompany echoic repetitions of what had just been said, were easy to paraphrase as explicitly metalinguistic constructions, and resisted paraphrasing as sentence-internal logical negations. In contrast, there were no early uses of *not* that showed a similar profile. It is possible that the earliest *no*s coded as denials are artifacts of the imperfect process of trying to guess what a child was thinking from what they said.

In any case, and crucially for our purposes, there was no difference in any of these effects between adoptees and typical first-language learners. This means that whatever explains the emergence of denial *no* and *not* in the production of typically-developing infants also must explain that same trajectory in older, more conceptually mature adoptees. If there is a conceptual limitation on children's acquisition of denial meanings, that limitation would have had to be resolved before children entered our study. Critically, it could not explain why the patterns of denial production over the course of language learning are the same in infants as in internationally-adopted preschoolers.

Constant Production of Rejection and Nonexistence over the Course of Development

Unlike the proportion of denials, the proportion of children's utterances expressing rejection and nonexistence remained constant, even as children produced increasingly longer utterances. Given this, as well as previous findings that expressions of rejection and nonexistence emerge relatively early in language learning (Bloom, 1970; Choi, 1988; Nordmeyer & Frank, 2018; Pea, 1980), it is likely that children had already reached a stable state in their ability to think about and express these meanings by the time they were enrolled in this study. Thus, the roughly constant proportion of children's utterances expressing these meanings may just reflect the frequency with which children need to express them, rather than their capacity to do so.

In this light, we can also make sense of the finding that adopted preschoolers produced fewer overall expressions of nonexistence than infant learners. If the frequency of expressing nonexistence merely reflects the frequency of a child's need to express nonexistence, then the fact that adoptees are ~2 years older than control infants may account for that need being lower. Where a 2-year-old might run out of crackers and complain, "no crackers", a 4-year-old might simply help themselves to more.

On its face, a constant rate of production of rejection and nonexistence over development seems to differ from previous studies of production, which have found that children's frequency of producing rejection starts high and falls rapidly with language development (e.g., Bloom, 1970; Nordmeyer & Frank, 2018). However, these studies examined rejections as a proportion of all *negations*, while we looked at rejections as a proportion of all *utterances*. Thus, these findings are in fact consistent with each other: rejections as a proportion of all utterances remain constant over early language development but decline as a proportion of all negations—due to an increase in the expression of denial.

A Linguistic Limit on Learning Negation

If a conceptual bottleneck cannot account for the difficulty of learning to express logical negation, then the bottleneck must be linguistic. It is not difficult to imagine that learning the mapping between negation words and their meanings might be a very difficult task, especially for a learner who does not yet have extensive knowledge of the rest of their language. Consider again a learner trying to interpret the statement, "Hands are not for hitting", before they have the ability to evaluate the corresponding affirmative statement, "Hands are for hitting". How would this learner infer that the word *not* means *reverse the truth value of the sentence*?

Underscoring the difficulty of this task, recent evidence has shown that when adults—who surely have the concept of negation—were presented with a silent video in which parents produce a logical denial negation in conversation with their children, they rarely guessed that the parent in the video said *no* or *not* (Gomes et al., 2023). In contrast, when parents used *no* to express prohibition (as in “No, don’t touch that”), adults correctly guessed that *no* was used in more than half of cases. However, when adults were instead shown videos with subtitles transcribing the rest of the utterance in which a denial negation appeared (e.g., “Hands are __ for hitting”), they were much more likely to correctly guess that a negation word had been used.

These findings suggest an explanation for the pattern we see in children’s production. Children’s earliest uses of negation express limited meanings like rejection (which may be a child’s way of prohibiting; see Gomes et al., 2023) because those are the meanings that are easiest to identify without knowing much of the rest of the language. Children must then learn a lot more about their language (e.g., word order, verb meanings, and tense marking) before they have enough information to infer that negation words have the additional meaning of logical negation.

If the major limit on children learning the meanings of negation words is the task of learning the words themselves, that could also explain the large differences across languages in the earliest production (Bloom, 1970; Çabuk-Balli et al., 2025; Choi, 1988; Frank et al., 2016; McNeill & McNeill, 1968; Tam & Stokes, 2001; Vaidyanathan, 1991) and comprehension (Austin et al., 2014; De Carvalho et al., 2021; De Carvalho & Dautriche, 2025; Feiman et al., 2017; Szabó & Kovács, 2025) of denial negation. Differences in the transparency of the syntax or in the degree of lexical overlap between different functions of negation across languages might have large effects on how difficult it is to learn the mapping between negation words and their meanings (for review, see McDermott-Hinman & Feiman, 2025). If there is no common conceptual limit, then there is no reason to think that children learning different languages would arrive at the meanings of negation words at the same time. And indeed, they do not.

The Possibility of First-Language Interference

Internationally-adopted preschoolers are different from infant first-language learners and infant adoptees not only in being several years older, but also in having already made significant progress in learning one language. It is therefore possible that any difference between the groups results not from adoptees' greater conceptual maturity, but from prior practice in language learning. This may, for instance, be part of the reason that adoptees proceed so much more quickly in overall language acquisition.

Beyond any effect of adoptees' prior language knowledge on language acquisition overall, it is possible that there was some specific effect, either positive or negative, of prior language learning on acquiring negation in particular. If this effect was negative—that is, if having learned a language previously interfered with adoptees' ability to acquire English negation—then such an effect might have canceled out any advantage adoptees derived from their greater conceptual maturity. While not impossible, such an account is unlikely, as any negative effect would need to have precisely cancelled out a positive effect across MLUs. Another possible effect of first-language interference is a facilitation effect—for instance, that having already mapped a truth-functional operator to a word in one language, it is easier to do so in another. Moreover, the Russian negators (*не* [n^je], ни [n^ji], and *н*ет [n^jet]) also have significant phonological overlap with the English negators *no* and *not*. This similarity could have offered a significant boost to Russian-speaking adoptees.

Instead, we found that the parity between preschool-aged international adoptees and infant first language learners remained even when restricting the sample to the six Russian-speaking adoptees in Study 2. Strikingly, despite multiple potential advantages, Russian-speaking adoptees were unable to determine which words in English express logical negation until they had learned enough English to make that inference possible.

Negation Differs from Other Abstract Concepts that Older Children Do Learn Earlier

Older adoptees' and typical infants' converging acquisition of negation words suggests that the concept of negation is unlike other abstract concepts that do seem to require conceptual development after the onset of word learning (and that older adoptees do learn earlier; Snedeker et al., 2012). What is it that makes words like *hungry* and *yesterday* more difficult for infants to learn, but doesn't similarly interfere with their ability to learn negation words? One possible answer is that words like *hungry* and *yesterday* belong to an open class of words whose meanings, while they refer to intangible concepts, are grounded in experience. This sets these abstract words apart from the closed class of logical operators like *no* and *not*, which do not refer to the world, but rather derive their meaning through their effects on the words and phrases with which they compose. Thus, *no* and *not* belong to a finite class of logical primitives that could be innately available to thought, while *hungry* and *yesterday* belong to an open class of concepts that must be learned through experience with the world. Adoptees, who have more experience with the world, might have an advantage over typical learners in learning these open-class words, but no corresponding advantage in learning words expressing logical primitives like negation.

On the other hand, it may be that the concept of negation is not innately available, and must be acquired, just like the meanings of *hungry* and *yesterday* must be. Because the task of mapping the meaning of negation to language is uniquely difficult, for all the reasons discussed above, the difficulty of the language learning task could swamp the difficulty of the concept learning task. As soon as a child has the ability to think about the concept HUNGRY, they will be in a position to learn the meaning of the word *hungry*. In contrast, regardless of their ability to think about the concept of negation, a child must learn some of their language before they are able to learn the meaning of negation words. Therefore, it is possible that children do need to learn the concept of negation, but by the time they have acquired the linguistic knowledge necessary to learn the meanings of negation words, they have already completed that learning. Thus, by the time they are linguistically equipped to learn the logical meanings of negation words, preschool-aged adoptees and typical first-language-learners face identical tasks: they just have to learn the mapping between their concept of negation and the words that express it.

Constraints on Generality

The present studies were conducted entirely with children learning English, leaving open the possibility that older adoptees and first-language learners might differ in their acquisition of negation in other languages. In particular, future work should examine languages with easy-to-learn negation systems as the ideal test bed for identifying any effect of conceptual development. In addition, the adoptees examined were drawn only from China, Korea, and Eastern Europe. We cannot conclude that children adopted from other linguistic environments would necessarily exhibit a similar pattern of acquisition. Finally, the dense longitudinal data we examined allowed us to carefully track negation acquisition in each child, but the resources needed to collect and classify such data limited our sample size to a small number of children, whose conceptual and linguistic abilities may not be representative of the general population of language learners.

Conclusion

Why is it hard for children to learn the words to express negation? Is it that young children need to acquire the concept of negation first, before they can learn how to label it? Or is it that, even when one has this concept, it is hard to figure out how a language expresses it without first understanding enough of the rest of a negated expression to tell what it is about?

While both conceptual development and language learning are plausible limits on learning to express negation, we found no evidence for the role of conceptual development, but strong evidence for the role of language learning in increasing the logical uses of negation words. Older children who have been adopted into an English-speaking household and are learning to speak English for the first time learn to express negation in much the same way as infants learning their first language. This suggests that the concept of negation is available by the time children begin to reliably say one-word utterances.

Is the concept of negation innate? More specifically, is it available prior to any language learning at all? Our findings are consistent with this possibility, but they do not rule out the possibility that infants learn the concept of negation before they start learning the language for it. Some have suggested that children may have at least precursor concepts to logical negation by 17 months (Feiman et al., 2022), or even by 12 months (Cesana-Arlotti et al., 2018; see McDermott-Hinman & Feiman, 2025, for review). It remains unclear, however, whether these concepts constitute full logical negation, or whether additional development is still necessary. Our findings indicate that, by the time children are beginning to string words together, the full concept of logical negation is likely already in place.

It is remarkable that a concept as abstract as logical negation does not seem to pose any particular difficulty to young language learners. Negation is expressed in English using different word forms, in a wide variety of syntactic contexts and with different pragmatic functions. Nevertheless, as soon as they have the requisite language knowledge to understand the context surrounding a negation word, children can map the concept of logical negation to it, and to begin using it to deny the truth of propositions.

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Appendix A

In the model discussed in Study 2 predicting production of Denial from Group, MLU, and Utterance Length, as well as their two- and three-way interactions, there was additionally a large and significant main effect of Utterance Length ($\chi^2(1) = 110.73$, $p < .001$)—longer utterances were more likely to be coded as Denials. Furthermore, there was a significant interaction between Group and Utterance Length ($\chi^2(1) = 40.50$, $p < .001$)—the effect of Utterance Length was larger in Adoptees than Control infants. There was also a marginally significant three-way interaction between Group, MLU, and Utterance Length ($\chi^2(1) = 3.70$, $p = .054$)—the difference between the groups in the effect of Utterance Length might be greater at higher MLUs. This three-way interaction was not present in Coder 2's data ($\chi^2(1) = 1.56$, $p = .21$). Post-hoc tests of Utterance Length at each treatment-coded level of the Group variable revealed that the proportion of Denials was greater for longer utterances in Adoptees ($\beta = 0.12$, Z = 8.29, $p < .001$) but not Controls ($\beta = 0.02$, Z = 0.66, $p = .51$). The interaction between Utterance Length and MLU was not significant for Adoptees ($\beta = 0.03$, Z = 1.52, $p = .13$) or Controls ($\beta = -0.04$, Z = -1.31, $p = .19$) for Coder 1. However, for Coder 2, the interaction between Utterance Length and MLU was significant for Adoptees ($\beta = 0.067$, Z = 3.24, $p = .001$) but not Controls ($\beta = 0.02$, Z = 0.53, $p = .60$).

For Adoptees, but not Controls, longer utterances were more likely to express Denial, even controlling for the child's overall MLU. One possible explanation for this pattern is that, though Control infants have the concept of negation, they still struggle with the cognitive demands of simultaneously thinking and expressing these thoughts. To form a negated thought requires performing a compositional operation combining negation with the proposition being negated, which may place demands on executive functioning capacities like working memory or inhibitory control.

Perhaps young children have, separately, the concept of negation, and the ability to produce longer utterances, but combining the additional difficulty of applying negation in thought with the task of formulating a longer sentence is beyond them. Supporting the possibility that the need to process an abstract relation like negation might cause children to produce otherwise shorter and less complex utterances, Bloom, Miller, & Hood (1975) found that 2-year-olds were more likely to elide VP constituents when a sentence contained a negation than when it did not. In contrast, though Adoptees may have the same conceptual and linguistic resources as Controls, they are older and thus have more developed executive functioning capacities, and so the expression of Denial may be less demanding for them. Thus, it may impede less their otherwise equivalent ability to produce longer sentences.

While in some sense this account describes a difficulty with the concept of negation, the difficulty is a question of performance, not competence. Controls still produce the same overall proportions of Denial utterances as do Adoptees, they just produce them using, on average, shorter utterances. Thus, this finding remains consistent with our conclusion that the major bottleneck on children's acquisition of negation is primarily linguistic and not conceptual, but it does introduce an additional layer to consider: it is possible to have a concept available to thought and mapped to words in your language, but for the expression of it in language to nevertheless be resource intensive.

Figure A1

Proportion of Denial Utterances by Utterance Length Across MLU Bins

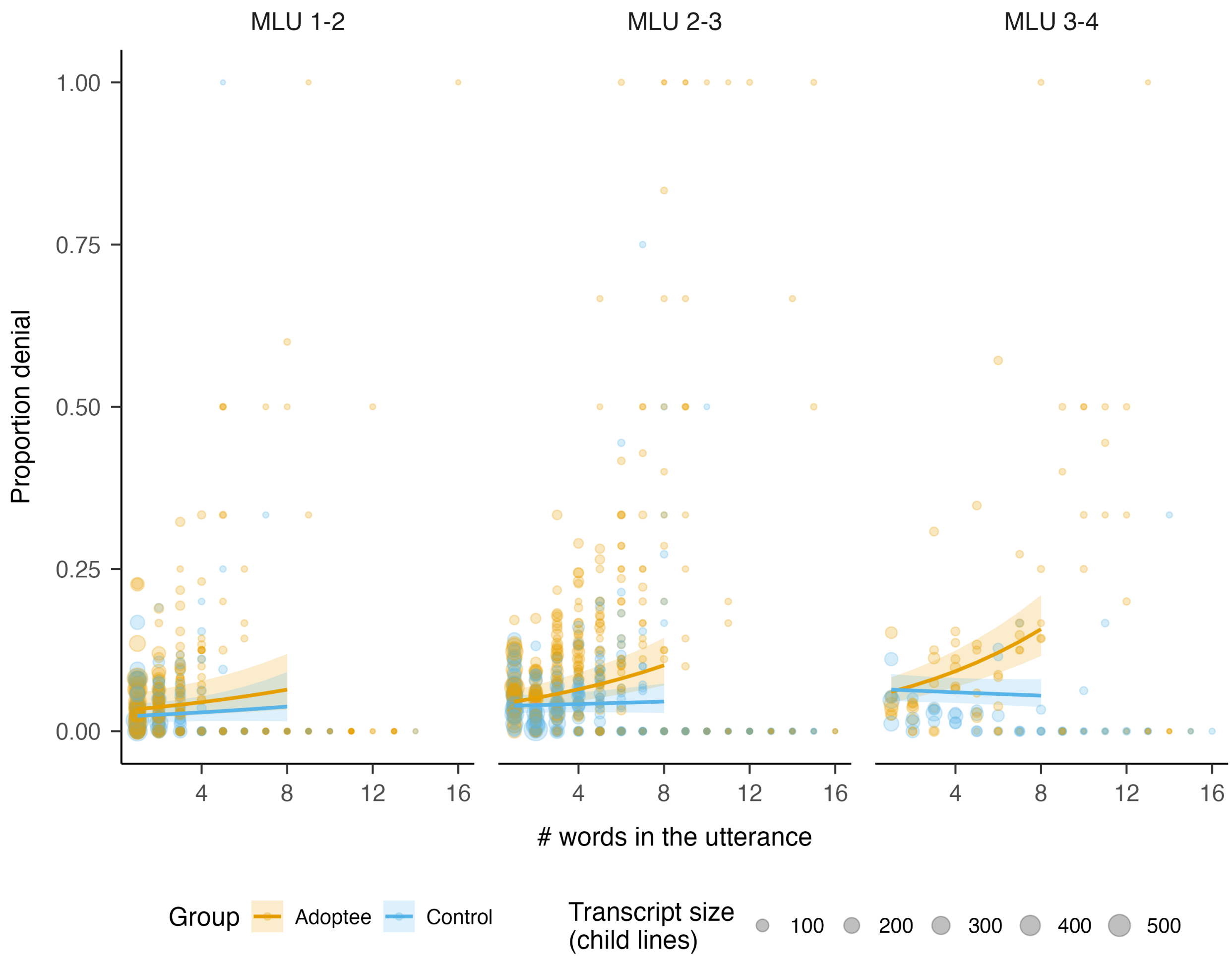

Figure A1. The proportion of Adoptees' and Controls' utterances of a particular length expressing Denial in transcripts with MLUs between 1 and 2, between 2 and 3, and greater than 3. Each filled dot indicates the subset of a speech sample with utterances of the relevant length (e.g., 4-word utterances) with size corresponding to the number of child utterances in the sample that fit that specification. Red represents adoptees, blue represents controls. Curves show predicted values derived from parameter estimates of the mixed-effects logistic regression model predicting Denial production with factors for MLU, Group, and number of words, as well as their two- and three-way interactions, and error bars show 95% confidence intervals.

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