Different paths:

Changes in second-language acquisition between three and five years of age

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Abstract

These studies explore the effects of cognitive maturation on language development by examining the acquisition of English in internationally-adopted preschoolers. Parental reports (CDI) were collected from 48 preschoolers, within the first year after they were adopted from China or Eastern Europe. Children who were adopted at two or three years of age showed the same developmental patterns in language production as monolingual infants (matched for vocabulary size). Early on, their vocabularies were dominated by nouns and social words and the proportion of predicates and closed-class words increased with age. Thus shifts in lexical composition appear in older learners and are unlikely to reflect the development of new conceptual resources. Children who were adopted at four or five deviated from this pattern, acquiring fewer nouns and more predicates in the early stages of acquisition. Effects of the child's birth language on the acquisition of English were limited to the older preschoolers, suggesting that they employ different strategies in word learning. In both groups, grammatical development and lexical development were synchronized in precisely the same way that they are in infancy, raising the possibility that word production and grammatical production are causally connected.

Keywords: language development, international adoption, word learning, language production, nouns, verbs, critical periods, syntactic complexity

In the *Biological Foundations of Language* (1967), Lenneberg argues that the course of language acquisition is shaped by a biological capacity that matures over the first two to three years of life, reaches a stable state in early childhood, and then begins to deteriorate at the onset of adolescence. Thus Lenneberg's critical period hypothesis has two parts: 1) the maturation of language abilities accounts for the predictable set of milestones that characterize early acquisition and their correlation with biological growth and motor development and 2) the maturational decline of language accounts for limited success of late language learners and the effect of age on the likelihood of recovering from aphasia.

In the past twenty years, research inspired by Lenneberg has largely focused on the second part of this hypothesis. Numerous studies have confirmed that ultimate attainment declines as a person's age of acquisition increases (Flege, Yeni-Komshian, & Liu, 1999; Hakuta, Bialystok, & Wiley, 2003; Johnson & Newport, 1989; Newport, 1990). These declines in attainment are accompanied by qualitative differences in language processing and language acquisition in older learners (Clahsen & Muysken, 1996; Hahne & Friederici, 2001; Weber-Fox & Neville, 1996). Nevertheless the debate rages on about the proper interpretation of these findings and what the definition of a critical period should be (Birdsong, 1999; Hakuta et al., 2003; Newport, Bavelier, & Neville, 2001).

In contrast, the present study is inspired by the first part of Lenneberg's hypothesis. Early language development is marked by a series a qualitative shifts. Infants initially speak in single-word utterances, before they begin to combine words. Young language learners initially produce sparse telegraphic utterances consisting mostly of nouns and verbs and then gradually add in the grammatical morphemes. A central question in language acquisition is what causes children to move through these phases. Lenneberg argued that these intermediate stages reflect the gradual maturation of children's linguistic capacity. Young children's utterances are short and sparse because of their cognitive limitations. This is one example of a *developmental hypothesis* for language development (Snedeker, Geren & Shafto, 2007). Theories of this kind attribute the order of acquisition or the emergence of new abilities to changes in the learner which are independent of the child's experience with a given language. Immaturity constrains language acquisition, limiting the kinds of words that a child can learn, the kinds of representations she can create, or the kinds of utterances she can produce. When these roadblocks are removed, either by biological maturation or cognitive development, children can acquire new linguistic abilities. In contrast, *contingent-acquisition hypotheses* attribute the order of acquisition to the interdependence of different linguistic representations or processes. The emergence of new abilities is driven by the child's growing knowledge of the language. Specifically, if knowledge of form A is necessary for acquiring form B, then the acquisition of B will have to await the acquisition of A.

In developmental theories, the initial stages of language acquisition reflect cognitive immaturity, while on the contingent-acquisition hypothesis they are viewed as necessary steps in decoding the target language. In developmental theories, the emergence of new linguistic abilities can be driven by the maturation of domain-specific abilities (Wexler, 1998) or the acquisition of new cognitive skills (Shore, 1986). In contingent-acquisition hypotheses, new linguistic abilities result from the child's growing knowledge of language, which may have been acquired via domain-specific mechanisms that evolved to support language (e.g., Snedeker & Gleitman, 2004) or through domain-general associative processes (e.g., Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002).

Such questions are difficult to explore because in typical development language acquisition and cognitive maturation are systematically confounded. International adoption provides the opportunity to disentangle these variables. Children who are internationally adopted as preschoolers encounter a language learning challenge that is similar to that of an infant: they are exposed to child-directed speech in the context of daily routines and must learn the new language to communicate with their families despite little access to bilingual informants and limited metalinguistic abilities (Gombert, 1992). However, these children are more cognitively advanced and physically mature than their infant counterparts and have already started to learn one language. Our research compares language acquisition in internationally-adopted preschoolers and monolingual infants (Geren, Snedeker, & Ax, 2005; Snedeker et al., 2007; Snedeker et al., in press). Our goal is to determine what role cognitive development and maturation play in typical language development by examining how acquisition proceeds when these road blocks have been removed.

In our previous work, we explored two facets of early language acquisition that could potentially be explained by either a contingent-acquisition hypothesis or a developmental hypothesis. The first is the systematic shifts that occur during word learning in infancy. Early vocabularies are dominated by social routines and nouns that refer to people, animals, and moveable objects. Although adults speak to children in full sentences, complete with verbs and function words, these elements are initially underrepresented in the child's lexicon (Bates, Dale, & Thal, 1995; Gentner, 1982). This input-output disparity can be plausibly attributed to the conceptual limitations of young children (Huttenlocher, Smiley, & Ratner, 1983; Macnamara, 1972). Perhaps the relative dearth of verbs and adjectives is attributable to the infant's inability to conceive of relations, states or actions, while the overabundance of nouns is attributable to the conceptual primacy of object categories.

Alternately the changing composition of children's lexicons could reflect linguistic rather than conceptual growth (Gillette, Gleitman, Gleitman, & Lederer, 1999; Snedeker & Gleitman, 2004). An infant who is just breaking into language has to learn the meanings of words by observing the situational contexts in which they are used. Older children, who have already acquired sizeable vocabularies, can also use the sentence in which the word appears.

Our second focus was on the transition to combinatorial speech and growing complexity of children's utterances. For many months after they begin speaking, most infants primarily produce single word utterances. The appearance of word combinations has been attributed to motor and cognitive development and linguistic maturation, as well as the accumulation of linguistic knowledge (Bates et al., 1995; Bloom, 1973; Shore, 1986). At around 24 to 30 months, children show a second burst of syntactic activity, adding determiners, auxiliaries and inflectional markers to their formerly sparse utterances (Brown, 1973). Curiously, both of these shifts are strongly correlated with productive vocabulary size, raising the possibility that lexical growth is causally related to syntactic development (Bates & Goodman, 1997). Alternately, both lexical and syntactic acquisition could depend upon the development of some other cognitive ability that independently influences the pace of acquisition in each domain. If the synchrony between lexical and grammatical development reflects a direct causal link, then it should persist in maturationally-advanced learners. In contrast, if the correlation is created by rate-limiting development in another domain, then it should be possible to find disassociations in older learners.

In the remainder of the introduction, we briefly review the prior work on second language acquisition in early childhood, and then we describe the findings of our previous studies and the questions that they left unanswered.

Second Language Acquisition

The role of maturation in acquisition is a central question in the field of second-language acquisition. Dozens of studies have compared first-language acquisition in infants with second-language acquisition in older children and adults, uncovering both similarities and discrepancies (see Clahsen, 1990; Freeman & Freeman, 2001 for reviews). But the vast majority of these studies are not well-suited for testing developmental hypotheses for two reasons.

First, most of this research has been conducted with adults or children over six years of age. Developmental hypotheses claim that cognitive changes during the first few years of life shape the course of language acquisition. When we compare infants with adults, we cannot isolate these early effects from the age-related changes that occur during middle childhood and adolescence. Several lines of evidence suggest that developmental changes after the age of six substantially alter the process of language acquisition. Older children and adults initially learn more quickly (Snow & Hoefnagel-Höhle, 1978) but reach a lower level of ultimate proficiency (Hakuta et al., 2003; Johnson & Newport, 1989). They may also acquire language using different cognitive processes and neural circuits (Ullman, 2001; Wartenburger et al., 2003; Weber-Fox & Neville, 1996). Between the ages of five and eight the ability to consciously consider and manipulate linguistic units develops rapidly (Gombert, 1992). These explicit metalinguistic skills may make children more deliberate language learners, leading them to rely on direct instruction and bilingual informants. Adults and older children also have longer verbal memory spans, which could allow them to memorize longer chunks of utterances (Dempster, 1981, 1985; Newport, 1990; Schneider & Bjorklund, 1998).

There is, however, a small body of research on second-language acquisition before the age of six. While many of these studies compare first and second language learners, none of this work, to the best of our knowledge, explicitly tests the developmental hypothesis. Instead recent studies in this area focus on whether child second language learners produce the same kinds of errors as adult second language learners. Evidence that they do so is generally taken to support the claim that there is a critical period for the ability in question which begins to close during the preschool years (see Meisel, 2009). Most of this work has focused on the development of syntax and inflectional morphology. The findings suggest that preschoolers do not make errors in acquiring syntactic distinctions that are marked by changes in word order, even relatively complex ones such as subject-verb inversion or verb placement in V2 languages like German (Blom, 2006; Haznedar, 2003; Hulk & Cornips, 2006; Rothweiler, 2006). However, they do make errors that are similar to adult learners in using verbal inflection, gender marking and clitic pronouns (Granfeldt, Schlyter, & Kihlstedt, 2007; Haznedar, 2003; Hulk & Cornips, 2006; Meisel, 2009) (Pfaff, 1992). In reviewing this evidence, Meisel (2009) concludes that there is a critical period for acquiring syntactic parameters related to these inflectional phenomena. This critical period, he argues, begins to close during the preschool years which negatively impacts children who begin acquiring a new language at or after three years and seven months.

Needless to say, this conclusion is controversial. First, the interpretation of many of the error patterns is unclear. While Meisel concludes that the clitic errors in preschoolers learning French are similar to adults and different from first language learners, Granfeldt and colleagues suggest that these errors may characterize simultaneous bilinguals as well (Granfeldt et al., 2007). Similarly, others have argued that the low rate of gender and inflectional errors in preschoolers compared to older learners suggests that any critical period for acquiring these categories occurs much later (Blom, 2006; Möhring, 2001).

Several features of these studies limit the conclusions that we can draw. Many of the studies have very small sample sizes (e.g., fewer than 10 children in the critical group) creating uncertainty about how robust and consistent these age differences are (but see Meisel, 2009 and Blom, 2006). Few of the studies include a control group of first-language learners, and those that do generally use a group that is matched in age rather than level of linguistic ability. Thus what appear to be qualitative differences in preschool learners could simply be developmental lags reflecting their late start and more limited input in the second language.

Finally, prior studies have used second-language learners who are in linguistic environments that are radically different from infants, making it unclear whether differences in acquisition are due to maturity or to differences in the learners' input and motivations. The preschool learners in these studies acquire their second language in one of three ways: 1) they live in a country in which their birth language is spoken but are sent to a preschool in which instruction occurs in the second language; 2) they are children of immigrants who were born in a country in which the second language is spoken but were only introduced to it when they entered preschool; or 3) they are children (often of academic parents) who are relocated to a country in which the second language is spoken and who begin acquiring it on arrival. In all three cases, the children typically continue to use their birth language in the home and may continue using it with their friends outside of school. Their primary exposure to the second language is likely to occur on the playground and in the classroom. Most researchers would consider this naturalistic acquisition because the children are not typically receiving direct instruction in the second language.

School, however, provides a very different social context than the home, which could potentially influence the course of language development. Lily Wong Fillmore pursued this intuition in her study of the acquisition of English by 5-7 year old children who had emigrated from Mexico to California (1976). She found that these children confronted an input situation radically different from that of young infants. Adult input came from classroom teachers who were typically communicating with the entire class at once. Thus their utterances tended to be highly formulaic and focused on classroom management. A richer form of input came from friends and classmates who were native speakers. Wong Fillmore notes that under these conditions language acquisition is intimately linked with the need to maintain reciprocal social relations. Childhood friendships are voluntary and fragile relationships, which can easily dissolve when communication breaks down. This creates a strong pressure for learners to find ways to feign competence and engage their peers until they develop fluency in the second language. Wong Fillmore argued that the children in her study did this by quickly learning a small set of frozen forms that allowed them to regulate interactions ("How do you do this?" "I don't wanna play with this one."). Consequently, their developmental path deviated radically from first-language learners. The children did not go through a one-word stage, they did not produce telegraphic utterances, and they showed little growth in their mean length of utterance during their first year of school.

Our research differs from prior work on child second-language learning in two critical respects. First, we are examining a population—internationally-adopted children—who are placed in a language-learning situation that more directly parallels that of infants. Like infants they learn English in the context of playing, eating and arguing with their family members. Because the children in our studies are being raised in monolingual English-speaking homes, they have little or no access to bilingual informants and no other language that they can use to meet their communicative needs. Thus, unlike the children in most second language studies, they do not maintain their birth language. In a prior longitudinal study, we found that after two months, most adopted preschoolers were speaking entirely in English (Snedeker et al., in press). Most of their parents reported that, by one year in the U.S., their child knew fewer than five words in their birth language. By adulthood, internationally-adopted children do not have any conscious access to their birth language and show no cortical responses that distinguish it from an unfamiliar language (Pallier et al., 2003).

Thus this population allows us to examine the effects of age of acquisition on the course of acquisition, independent of differences in the input that children receive or the challenges (social or cognitive) of acquiring one language while a prior (and typically dominant language) continues to be used. Prior studies have demonstrated that the level of proficiency in second-language learners is correlated with their use of the second language (Flege, Frieda, & Nozawa, 1997; Flege et al., 1999). Such differences in proficiency may account for many of the observed differences between second language processing in early and late child learners (Chee, Hon, Lee, & Soon, 2001; Perani et al., 1998). In child learners, proficiency is correlated with language use in the home (Flege et al., 2006; Jia & Fuse, 2007). In turn, the language used in the home is confounded with the age of acquisition, with older children using and hearing their second language less than younger children (Jia & Aaronson, 2003). Thus, in typical naturalistic second-language learning environments, variation in linguistic environment could result in spurious maturational effects. In the context of adoption, this confound is removed.

Second, our research has focused primarily on lexical acquisition and its relation to grammatical development, issues which have largely been ignored by those studying second-language acquisition in childhood. This lacuna reflects the field's focus on critical-period effects and the widespread assumption that there is no critical period for lexical or semantic development (see e.g., Meisel, 2009). This belief is based on the observation that we continue to acquire words throughout our lives and a handful of studies which show that late learners show the same patterns of brain activity in response to semantic violations as native speakers (e.g., Weber-Fox & Neville, 1996). But three considerations suggest that global optimism about late lexical acquisition is unwarranted. First, many of the errors made by later learners appear to be lexical in nature. For example, preposition usage errors are rampant in the writing of intermediate and advanced ESL students, occurring in 18% of all sentences and accounting for 29% of all errors (Bitchener, Young, & Cameron, 2005; Dalgish, 1985). These errors reflect cross-linguistic *lexical* variation in the meanings of spatial prepositions, their extension to nonspatial uses, and verb-specific selectional constraints, all of which make pronoun usage a tricky computational problem (Bowerman & Choi, 2001; Chodorow, Tetreault, & Han, 2007; Levin, 1993). Second, researchers who have attempted to tease apart lexical and syntactic factors in grammaticality judgments have found that violations which are, in part, lexical actually pose more difficulty to late learners than violations which are purely syntactic (Flege et al., 1999), perhaps because lexical regularities by definition apply in fewer contexts and have exceptions. Finally, imaging studies of lexical processing in late vs. early bilinguals find evidence for differences in the brain responses to lexical repetition (Isel, Baumgaertner, Thrän, Meisel, & Büchel, 2009). Thus a more careful examination of developmental changes in lexical acquisition is warranted.

Early language development in internationally-adopted preschoolers

Our research has examined two aspects of early language acquisition that could plausibly be explained by either a developmental hypothesis or a contingent-acquisition hypothesis: the systematic shifts that occur during early lexical development and the growing complexity of children's early utterances. To explore these phenomena, we conducted two studies: a cross-sectional study of 27 children who were adopted from China as preschoolers (Snedeker et al., 2007) and a longitudinal study that closely tracked the language acquisition in nine children—two from China and seven from Russia—over the course of the first year (Snedeker et al., in press). These children showed the same shifts in lexical composition as monolingual infant controls. Their early vocabularies were dominated by social routines and nouns. As vocabulary size increased, the proportion of predicates and closed-class words increased. This suggests that changes in lexical composition in infancy are not attributable to the development of new conceptual resources. Instead they reflect the relative difficulty of acquiring different types of words from child-directed speech and the nature of the information that is required to do so. Second, we found that lexical development and grammatical development in this population were synchronized in precisely the same way that they are in typically-developing infants. The transition to combinatorial speech began when productive vocabulary size was around 100 words and the complexity of utterances in the infants and the preschoolers began to rise around the time that they acquired 200 words. This suggests both that the one-word stage is not merely a side effect of cognitive immaturity and that lexical-grammatical synchrony is likely to reflect causal relations between the two domains (Bates & Goodman, 1997; Gleitman, 1990).

The differences between the preschool learners and the infant controls were equally informative. Preschoolers learned much faster, initially acquiring words at about four times the rate of infants. Thus, while many of the qualitative shifts in early production are not affected by maturation, the speed of learning clearly is. Our longitudinal study also revealed a few limited, but systematic, differences in the kinds of words that the children learned. Preschoolers learned words for temporal relations and units, as well as adjectives describing mental states and behavior, at an earlier stage of development than infants. This pattern suggests that, in these conceptual domains, cognitive development may set the pace for early language acquisition.

Two new issues are raised by these findings. First, these results suggest that language acquisition in preschoolers relies on roughly the same set of mechanisms as language acquisition in infants. If this is the case, then we should see few, if any, effects of the child's first language on their acquisition of English. Studies of young children suggest that, while cross-linguistic transfer can occur (e.g., Nicoladis, 2006), it is not a pervasive feature of bilingual acquisition. Instead young children appear to rapidly differentiate the languages that they are learning (see Nicoladis & Genesee, 1997 for review). In contrast, many theorists have argued that adult learners begin with the hypothesis that their second language is like their first (but with a different lexicon) and then gradually adjust this hypothesis as acquisition progresses (Eubank, 1993/1994; Schwartz & Sprouse, 1996; Vainikka & Young-Scholten, 1996)). This leads to a pervasive tendency to transfer semantic and syntactic structures from the first language to the second language (see Hawkins, 2001 for review). There has been little work on cross-linguistic transfer in second-language learners under the age of six, so we do not know whether transfer is common when a second language is acquired during early childhood.

Fortuitously, the most common birth languages for internationally-adopted children are Slavic and Chinese languages which are strikingly different in several respects. Slavic languages have free word order and complex inflectional morphology, while Chinese languages have a fairly strict SVO word order, no inflectional morphology, and few function words (Comrie, 1990). Consequently, the course of native language development is quite different. From an early age, children learning Slavic languages have variable word order and use inflectional morphemes (Smoczynska, 1985; Weist & Witkowska-Stadnik, 1986). Children learning Mandarin Chinese rapidly acquire the dominant word order but omit function words in mandatory contexts into the preschool years (Erbaugh, 1991). If the birth language influences second-language acquisition in this population, we would expect children from China and Russia to take radically different approaches to learning English. Our longitudinal study included children from both countries, but the small number of participants precluded any analysis of the differences between the two.

Second, our findings raise the question of just how long this period of infant-like learning lasts. While these studies were initially designed to explore maturational accounts for rise of language, they could also be relevant to understanding maturational accounts for its fall (the other half of Lenneberg's proposal). As we noted, prior work with child learners raises the possibility that the critical period for some aspects of syntactic development may occur as early as four years of age. Data on the effects of age of acquisition on adult language attainment provide some support for this conjecture, particularly in the areas of speech production and speech perception (Abrahamsson & Hyltenstam, 2009; Flege et al., 1999). But typically in these studies the number of participants who began acquiring the second language between the ages of two and six is quite small. Furthermore, it can be difficult to ascertain, twenty or thirty years later, precisely when a child began acquiring the second language. Did their exposure begin at the time of immigration or upon entering school? In the context of adoption, this question is easy to answer. The child experiences a complete shift from one language to another allowing us to precisely date the time at which acquisition begins.

In sum, the evidence to date suggests that there is a critical period, or a decline in plasticity, for some aspects of phonological and syntactic development that begins in childhood. If this decline does begin during the preschool years, then we might expect to see some effects in our measures. The CDI (Fenson et al., 2006) sentence complexity scale includes several items tapping inflectional morphology, a skill which Meisel (Meisel, 2009) argues begins to decline in children as young as 3;7. In addition, because word learning is dependent on both phonological processes (which represent lexical forms) and syntactic processes (which are involved in learning word meanings), we might expect that any decline in the plasticity of these processes would impact lexical development as well.

In our two earlier studies, we saw no evidence of such an effect. However, these experiments were not designed to address this question. In the longitudinal study, there were too few participants to robustly assess effects of age within the preschool group. The critical shifts happened in both older and younger preschoolers, but we lacked the power to determine whether they happened to the same degree. In the cross-sectional study (Snedeker et al., 2007), we took children as they came, and did not systematically balance time since adoption and age of adoption. In this set of children, the older learners began the study slightly later. Because of this, and because the older children acquired words more quickly, age of arrival and vocabulary size were systematically correlated. In fact, over 80% of our data points in the lowest vocabulary ranges came from children who arrived before their fourth birthday. Thus if there were maturational changes between the ages of 3 and 5 that alter the course of early lexical development, our prior studies could easily have failed to find them.

The present paper remedies that. We collected data from a much larger group of preschool adoptees (48 in the first study) and systematically balanced three factors. First, we divided the preschoolers based on the age at which they were adopted: children adopted between 2;5 and 3;9 were assigned to the younger preschool group while those adopted between 3;10 and 5;6 comprised the older preschool group. On Meisel's hypothesis (2009), most of the children in the younger group would be within the early critical period for the development of inflection while the older children would not. Second, we balanced the country of origin of the adopted children, collecting data from twenty four children who were adopted from Russia and twenty-four children adopted from China (evenly split across the two age ranges). Third, in each of these groups, we collected data from children who had been in the U.S. for less than 3 months, 4-6 months, 7-9 months or 10-12 months, to trace how vocabulary composition shifted over time for each age group and country of origin. Finally, as in our previous studies, we compared the adoptees to a group of U.S.-born infant controls who were matched to the preschoolers on the basis of their vocabulary size. Unsurprisingly, to balance all these factors, we had to collect a lot of data that we could not use in Study 1. However, this discarded data was put to good use in Studies 2 and 3.

For any given measure, three possible data patterns could emerge. First, we could find that both younger and older preschoolers show the same pattern of acquisition as the monolingual infant controls. This would confirm our previous work, providing further evidence against developmental hypotheses and in favor of contingent-acquisition hypotheses. Furthermore, the lack of a difference between the younger and older preschool group would suggest that that the mechanisms responsible for this shift do not undergo substantial qualitative changes during the preschool years.

Second, we could find that both younger and older preschoolers systematically diverge from the infants. For example, they might have a more diverse vocabulary at the earliest stages of acquisition or begin producing more complex sentences at an earlier age. Such a finding would be unexpected given our previous studies, but it would be consistent with developmental hypotheses, which suggest that the lack of these skills in infants reflects cognitive barriers which should be absent in both three-year-olds and five-year-olds. Alternately this pattern of deviance in both preschool groups could be interpreted as evidence for a critical period that starts coming to an end before age 2;6. For example, the late emergence of syntax relative to lexical development might be expected on versions of the critical hypothesis that invoke a distinction between declarative and procedural memory (Ullman, 2001).

Finally, the younger preschool group could follow the path of the infant learners, while the older group could diverge. This pattern would provide different answers to each of Lenneberg's questions. The presence of the shift in younger preschoolers (who are more mature than infant learners) would suggest that the emergence of this ability is not driven by maturation of the language capacity or general changes in cognitive development. However, the deviance of the older learners from this path would suggest that age-related changes have altered (or supplemented) the mechanisms responsible for this aspect of acquisition.

Study 1

Methods

Participants

The preschool group consisted of 24 children who adopted from China and 24 children adopted from Russia (or another Slavic-speaking country) between the ages of 2;5 and 5;6 inclusive. The infant control group included 24 children who had been adopted from China before 16 months of age and 24 children who were born in the U.S. and were being raised in monolingual English homes. Information about the age of adoption and current age of these groups appears in Table 1.[1]

Tables 1 & 2

To ensure that age at time of adoption and exposure to English were not confounded with the child's birth language, the preschool group consisted of three children in each cell of a matrix that crossed: 1) country of origin (China or Russia); 2) age at adoption (2;5-3;9, 3;10-5;6); and 3) time since adoption (0-3 months, 4-6 months, 7-9 months, 10-12 months). The infant controls were matched to the adopted preschoolers on the basis of vocabulary size. Each preschooler from China was matched with an infant from China who had a similar vocabulary size. Few children are adopted from Russia prior to 16 months of age, so the Russian preschoolers were each matched with a monolingual English speaking infant. The closest vocabulary match available was selected and the vocabulary size of the infant control was always within 15% of the vocabulary size of the preschool adoptee. Table 2 provides additional demographic information about our sample.

Information about the study appeared in: *Adoption Today* (a national magazine for adoptive families), in the online newsletters of regional chapters of Families with Children from China (FCC) and Families for Russian and Ukrainian Adoption (FRUA), as well as other newsletters and discussion boards aimed at families with internationally-adopted children. Families with preschool adoptees were invited to participate if their child was adopted between the ages of 2;5 and 5;6 and had been in the U.S. for less than one year. Families with infant adoptees were

[1] Five of the children in this study also participated in a longitudinal study (Snedeker, Geren, & Shafto, in press). This included 1 preschooler adopted from China and 4 preschoolers adopted from Russia.

invited to participate if their child was adopted before the age of 16 months and was currently younger than 34 months old. All the children adopted from China were believed to have initially been exposed to a dialect of Mandarin or Cantonese, though some of the children were reportedly exposed to regional languages as well (e.g., Wu dialects of Chinese). The Slavic language group consisted of 23 children from Russia and 1 child from Bulgaria, all of whom had been exposed primarily to their national language. We will refer to them as Russian adoptees for ease of exposition.

Three exclusionary criteria were used for both the preschool and infant groups. First, we excluded any family in which the parent regularly used a language other than English with the child. Families attending weekly classes or activity groups where the birth language was used were not excluded (see Table 2). Second, we excluded all children who had been diagnosed with a major developmental disorder, including Down syndrome, an autism spectrum disorder or mental retardation. Children who were reported to have developmental delays, language delays or attention deficit were not excluded, but this information was recorded (see Table 2). In most cases the diagnosis of a developmental delay was made by the child's pediatrician and it was unclear whether the methods that were used could reliably distinguish between a true cognitive delay and limited English proficiency. Third, children who had a sensory or motor impairment that might affect speech perception or production were excluded, including those with bilateral hearing loss or an uncorrected cleft palate. Children with hearing loss in one ear or with tubes for ear infections were not excluded (Table 2).

In order to get a group of participants that was matched for age of adoption and time since adoption, we recruited a much larger sample of children. In addition, we encouraged parents of adopted preschoolers to contribute additional observations until their child had been in the U.S.

for 12 months, and parents of infants were encouraged to participate until their child was nearing the ceiling of the CDI. Thus for many of the children more than one session was available for analysis. In these cases, we selected a session that included all the measures and that would fit into a cell that was not already full. For both age groups, the average session that was included in this analysis was the second that the child participated in (M=2.07 and M=2.30 for the preschool adoptees and infant controls, respectively). In Study 2, we return to explore this larger data set.

Measures

Our study was designed to be conducted through the mail so we could work with families from across the U.S. Most children who are internationally adopted arrive in the U.S. before 30 months of age, so the number of preschoolers who would be eligible for this study in any particular region is quite small (e.g., roughly 100-200 children per year in all of New England). All materials for the study were mailed to parents who collected the data in their home. Four measures were used: a background questionnaire, the MacArthur-Bates Communicative Development Inventory 2 (CDI), a videotaped speech sample, and a modified version of the Ages and Stages Questionnaire (ASQ). The background questionnaire was based on one used by Glennen and Masters (2002) and Pollock (2005). It asked about the child's history and health, their level of proficiency in their birth language, their adoptive family, their current language environment and their current use of English and their native language. This information was used to characterize our sample and to exclude children who did not meet our selection criteria.

We examined the early English development of the adopted children using the CDI (Fenson et al., 2006). The CDI is a parent report measure which includes a 680-item vocabulary checklist, questions about the child's early word combinations, and a forced-choice sentence-complexity measure that asks about the child's use of inflectional morphemes and closed-class words. The CDI is normed for children 16 to 30 months of age. However, it has also been used to track language development in older children with limited language skills (Berglund, Eriksson, & Johansson, 2001; Singer-Harris, Bellugi, Bates, Rossen, & Jones, 1997; Thal, O'Hanlon, Clemmons, & Frailin, 1999).

The speech samples were collected by the participating parent who was instructed to videotape herself interacting with her child for 45 minutes. Families were given a standard set of toys to play with while making the recordings. The speech sample was transcribed and used to validate the parental report of the child's language use and linguistic environment.

Our fourth measure was a parental report of children's cognitive, social and motor development. This measure was based on the ASQ—a set of parental checklists that are used to screen children between 2 months and 6 years for developmental delays that might warrant clinical attention (Bricker & Squires, 1999). The questions probe gross-motor, fine-motor, personal-social, problem solving, and language skills. We constructed a modified version of the ASQ by pooling the questions from the checklists for children between 12 months and 60 months and eliminating questions assessing language development and questions which require a linguistic prompt or response. To answer the questions on the ASQ, a parent would need to have extensive knowledge of her child's abilities in a wide range of contexts. For this reason, we did not send the modified ASQ to adoptive parents until their child had been in U.S. for three months. Parents of the infants who were born in the U.S. always filled it out at the same time as their session.

Results

Our analyses addressed four issues. First, to confirm our assumption that the adopted preschoolers were substantially more cognitively mature than the infant controls, we examined the parents' responses on the modified ASQ. Second, we explored whether age of adoption and country of origin influenced the pace of language acquisition in the adopted preschoolers. Next, to explore how cognitive development influences word learning we compared the vocabulary composition of adopted preschoolers and infants, with particular attention to the differences between the younger preschool group and the older preschool group. Finally, we explored whether lexical-grammatical synchrony persisted in older learners by examining the relation between measures of syntactic development and vocabulary size.

Assessment of Developmental Milestones (the modified ASQ)

The primary goal of this study is to examine how language acquisition proceeds in a population that is more cognitively mature than typical infant language learners. We recognize that post-institutionalized children are likely to have cognitive delays. The logic of our design simply requires that they be more cognitively advanced than infant learners who are passing through the same stages in acquiring English (i.e. between 16-30 months).

To assess this, we analyzed performance on the modified ASQ, calculating the percentage of milestones that each child had passed. Separate regression analyses were conducted for the infants and the preschoolers. In both groups, the child's current age accounted for a substantial portion of the variance ($R^2 = .681$, $p < .001$; $R^2 = .477$, $p < .001$ for infants and preschoolers, respectively) demonstrating that the modified ASQ is sensitive to development in this age range. In the infant group, there was a small interaction between the child's age and population (incremental $R^2 = .034$, $p < .05$). Curiously, the infants who were born in the U.S. appeared to develop slightly more slowly than infants adopted from China. This may reflect the gender composition of the adopted sample or the higher education level of the mothers. There was also a small effect of country of origin in the preschool adoptees (incremental $R^2 = .060$, $p < .05$). The parents of the children from Russia reported slightly fewer milestones than the parents of children from China, consistent with their higher level of expressed concern about their child's development (see Table 2). The difference in ASQ scores between the Russian and Chinese adoptees was equivalent to about 4 months of age.

Figure 1 here

The ASQ scores were submitted to an ANOVA with age group (infant or preschool adoptee) and half of sample (younger preschoolers & controls vs. older preschoolers & controls) as between participant variables. As Figure 1 suggests, there was a robust effect of participant group [$F(1,92)=99.55$, $p < .001$]. The preschoolers had passed 88% of the milestones while the infants had only passed 57%. There was also a significant effect of half of sample [$F(1,92)=15.03$, $p < .001$]. While there was no interaction between age group and half of sample [$F(1,92)=1.82$, $p > .1$], the effect of half of sample was carried largely by the preschoolers. The older preschoolers were considerably more advanced than the younger preschoolers [$F(1,44)=36.61$, $p < .001$] presumably because they were, on average, almost two years older (Table 1). In the infant group, there was a trend suggesting that the infants matched with the older sample might be slightly more advanced than the infants matched with the younger sample [$F(1,44)=2.93$, $p = .094$]. These groups of infants were pulled from the same population, thus any differences between them are likely to result from the vocabulary matching procedure. As we will see, the older preschoolers learned more rapidly than the younger preschooler hence their controls had slightly higher vocabulary levels and thus may have been more cognitively advanced. Critically, both the younger and older preschoolers had substantially higher scores on the ASQ than their controls [$F(1,44)=50.90$, $p < .001$; $F(1,44)=87.18$, $p < .001$, respectively].

<u>The pace of vocabulary acquisition</u>

A hierarchical stepwise regression was conducted on the total number of words that the child produced on the CDI vocabulary measure (CDI vocabulary size). Because the primary goal of this analysis was to explore the factors that influence the pace of acquisition in adopted preschoolers, only the children in the preschool sample were included. In our previous work, we found that vocabulary grew rapidly in the first months after adoption, but the pace of CDI vocabulary growth decelerated over the first year as the child neared the ceiling of this measure (Snedeker, et al., in press). In the first step, time since adoption was added as a linear predictor, to capture vocabulary growth, and quadratic predictor, to capture the deceleration. There was a large linear effect (R^2=.491, $p < .001$) and a smaller but reliable quadratic component (incremental $R^2 = .052$, $p < .05$). On average children were initially learning approximately 84 new CDI words a month, but this decreased on average by about 4 words each month.

In the second step of the regression, age at adoption was added as a predictor along with the interaction between age and both the linear and quadratic components of time. Then a backward regression was conducted to determine the best predictors. There were reliable interactions of age and time (incremental $R^2 = .067$). For every additional year of age, children were initially learning about 20 more words per month ($p < .001$). However, older children also had a faster deceleration in their CDI vocabulary score ($p < .05$). Figure 2 illustrates this by graphing the vocabulary growth curves for the younger and older half of the preschool sample.

Figure 2 here

Finally, in the third step of the hierarchical regression, we added the child's country of origin and its interaction with the linear and quadratic components of time. Again a backward regression was conducted to prune down the predictors. The effects of age at adoption remained in the model and an interaction between country of origin and the linear effect of time emerged (incremental $R^2 = .037$, $p < .05$). Children who were adopted from Eastern Europe were learning on average about 10 fewer words per month than children from China.

Vocabulary Composition

Next we explored the shifts in vocabulary composition that occur during early language development. The dependent variable in these analyses is the percentage of the words in the child's lexicon that belong to a particular category. For example, if a child knows 10 words and 6 are nouns then her noun percentage is 60%. All analyses were conducted as hierarchical stepwise regressions with the predictors that are simple metrics of vocabulary size entered in the first step. The relation between vocabulary composition and vocabulary size is robust and extensively documented (see e.g., Bates et al., 1995; Caselli, Casadio, & Bates, 1999). We selected our metrics of vocabulary size based on this literature. For example, prior studies have found that the proportion of nouns in children's vocabularies increases between 0 and 200 words and then declines. Thus we entered one predictor to capture the rise of nouns (vocabulary < 200 words, which is equal to the child's vocabulary if it is less than 200 words, but is equal to 200 if vocabulary size is higher) and another to capture the fall of nouns (vocabulary > 200 words, which is vocabulary size minus 200 words for children with more than 200 words, but 0 otherwise). Additional predictors were added to the model as sets. Specifically, when a group variable, such as age group, entered the model it was always accompanied by the interactions between that variable and the vocabulary size metrics for that model. Variation in vocabulary composition between groups is likely to involve both a change in the starting state and a change in the rate of growth over time. By entering the predictors in sets we ensure that we capture relations of this kind, which might not emerge in typical forwards stepwise regression.

In our initial analyses we compared vocabulary composition in preschool adoptees and infant controls collapsing across younger and older preschoolers and children adopted from China and Eastern Europe. Table 3 provides the results of these analyses. Vocabulary size predictors were entered in the first step of each regression. In the second step age group was entered along with all interactions between age group and metrics of vocabulary size. Finally, a backwards regression was conducted to determine which predictors were reliable. Four findings emerge from this analysis.

Table 3

First, the effects of vocabulary size on vocabulary composition accounted for a substantial portion of the variance in all analyses (R^2 = .754 to .317, all p's < .001), as they had in our previous studies (Snedeker et al., 2007; in press). Second, as in our previous longitudinal study (Snedeker et al., in press), we found that age did not have a reliable effect on the proportion of social words: in both groups these words were initially very common then dropped of steeply (the linear effect of vocabulary size) with the rate of decline decelerating as vocabulary grew (the quadratic effect). Third, we found that preschool adoptees learned many more words for time than typically developing infants, again replicating the findings of the longitudinal study.

But fourth, and most interestingly, we discovered that age group had a small but significant effect on the three other lexical classes. In the adopted preschoolers, the proportion of nouns did not grow as rapidly in the first 200 words. They learned more predicates (adjectives and verbs) at an early age and showed less of an increase in the predicate proportion as vocabulary size increased. Finally they learned more closed class items than the infants. These effects were surprising because they had not emerged in either of our prior studies which used the same method, similar analyses, and similar populations (Snedeker et al., 2007, in press). Interestingly, these are precisely the kind of effects that we would expect if infants encounter conceptual difficulty in learning relational words that are resolved during early language acquisition. However, the modest size of these effects (R^2 = .103 - .054) and the fact that they had not appeared in the previous studies suggests that they might be limited to a subgroup of the adopted children. Perhaps the oldest preschoolers in our sample are tackling language learning in a different way the younger preschoolers and succeeding with a wider range of lexical classes.

To explore this possibility, we conducted hierarchical regressions exploring the effects of three variables: 1) age group (preschool adoptees vs. infant controls); 2) half of sample (younger preschoolers and their controls vs. older preschoolers and their controls); and 3) an interaction term for age group and half of sample (which separates the older preschool group from both the younger preschool and the controls). We calculated the additional variance that each set of variables (independently) contributed to a model that included the vocabulary-size metrics, and then conducted a backwards regression to find the predictors that were most robust (Table 4).

Table 4

On the developmental hypothesis, we should expect effects of age group to dominate, demonstrating that preschoolers as a group have cognitive prerequisites that infants in the earliest stages of acquisition may lack. This is precisely the pattern that is observed for time words; age group accounts for more of the variance than the other factors, and only the effect of age group is reliable in the final model. In contrast social words, nouns, predicates, and closed class items show a very different pattern. In all cases, the interaction between age group and half of sample accounts for more of the variance than age group, and at least one of these interaction terms is reliable in the final model. In fact, only in the case of nouns is there any suggestion that age group has predictive value beyond this interaction. This pattern suggests that older preschoolers (adopted 3;10 - 5;6) are patterning differently than both the infants and the younger preschoolers (adopted 2;5 - 3;9).

Tables 5 & 6

To verify this, we conducted separate analyses of the younger and older preschoolers, comparing each to their respective controls. For the younger sample, there are robust effects of vocabulary size in every analysis but only in the case of time words is there a difference between the adopted preschooler and their controls (Table 5). In contrast for the older sample (Table 6), there are significant differences between the preschoolers and their controls in every measure of lexical composition (incremental R^2 = .054 - .316, p's < .005). These effects are illustrated in Figures 3 to 7.

Figures 3-7

In all groups, the proportion of social words is high at the beginning of lexical acquisition and then declines as vocabulary size increases (Figure 3). In the younger preschoolers and infants this decline is initially very rapid but then decelerates. In the case of the older preschoolers the initial proportion of social words is smaller, the drop off is less steep, and this deceleration is essentially absent. However, the vocabulary trajectory for social words is strongly shaped by participants with vocabularies under 50 words. Only one older preschooler fell into this category. When this participant and her control are removed from the analysis, the effects of age group are no longer reliable. Thus this pattern requires additional confirmation.

In the infant controls nouns initially make up about 40% of the words that the child knows (Figure 4). This proportion increases until it reaches a peak of about 60% when vocabulary size is 200 words and then declines to about 40% as the children near the ceiling of the CDI. This same pattern is observed in the younger preschoolers. In contrast the older preschoolers begin with fewer nouns (30%) and have a lower peak, suggesting that they are learning a wider variety of words early on. Consequently they also show a more gradual drop off. The scatter plots suggest that the differences in noun proportion between the older preschoolers and their controls are quite consistent across subjects and removal of a small number of observations (e.g., children with vocabulary sizes near 200 words) does not alter the pattern of the findings.

As Figure 5 illustrates, the proportion of predicates in the vocabulary of infants and younger preschoolers increases steadily from about 10% in the first 100 words to about 25% at 600 words. In contrast the older preschoolers have a high predicate proportion from the earliest sessions (about 20%) and there is little change in this as vocabulary size grows. Again the scatterplots suggest that this is fairly consistent across children.

The proportion of closed-class words is highly variable in the early lexicon (Figure 6). In infants, at around 300 words it becomes less variable and begins increasing. The younger preschoolers show precisely this pattern of growth. In contrast, the older preschoolers show an overall increase in the proportion of closed-class words at all vocabulary levels with considerably more variability across children. While the group difference does not appear to be driven by a small number of outliers, the extreme variability in this population suggests that these findings might be variable across samples.

Finally, the effects for time words mirror what we observed in the prior longitudinal study (Figure 7). Infants learn very few of these words in the initial stages of vocabulary acquisition but they emerge steadily as vocabulary size increases. In contrast, many of the preschoolers, both older and younger, learn these words earlier, elevating the time word proportion in this age group.

Lexical-grammatical synchrony

In infants the grammatical complexity speech is strongly correlated with the size of the productive lexicon. We explored the relation between CDI vocabulary size and the CDI sentence complexity metric in series of hierarchical regressions identical to the ones described above. The results were quite different. In our initial analysis, collapsing across the younger and older subsamples, we found no differences between the adopted preschoolers and infant controls (Table 3). Furthermore, there were no reliable effects of half of sample or interaction between age group and half of sample (Table 4), suggesting that both the older and younger preschoolers were patterning like infants in this respect. This was confirmed in the separate analyses of each group (Tables 6 & 7). In both the younger sample and the older sample there were strong effects of vocabulary size ($R^2 = .631$, $p < .005$; $R^2 = .730$, $p < .005$ respectively) and no apparent effect of age group. As Figure 8 indicates, at all ages performance on the sentence complexity measure is near floor until about 200 words, and then increases steadily with vocabulary size.

Figures 8 & 9

If children are combining words, the CDI also asks parents to report the three longest utterances that the child produced. To ensure that these effects were not unique to the sentence complexity measure, we performed a parallel series of regressions comparing the mean length of these utterances (in words) to the child's vocabulary size. Children who were not yet credited with combining words were given credit for utterances of 1 word long. If a child was said to be combining words but the parent did not provide any examples, the child was removed from this analysis along with her control. This resulted in the loss of three older preschoolers and their controls.

The results of these analyses tightly paralleled those for the sentence complexity metric (Figure 9). As children's vocabulary size increased, there was a linear increase in the length of their utterances ($R^2 = .669$, $p < .005$) with no evidence of any differences between preschool adoptees and infant controls ($R^2 = .008$, $p > .1$). This same pattern characterized both the older half of the sample and the younger half ($R^2 = .612$, $p < .005$; $R^2 = .691$, $p < .005$ for vocabulary size and $R^2 = .023$, $p > .1$; $R^2 = .009$, $p > .1$ for age group, respectively). Thus, despite their greater knowledge of closed-class words and predicates, the older preschoolers do not a produce longer utterances than infants and younger preschoolers with the same vocabulary size.

Discussion

The results of Study 1 confirm and extend several of our previous findings. As in the previous studies we found that preschool adoptees were more cognitively sophisticated than infants with the same level of English proficiency. They begin learning English quickly and start bumping up against the ceiling of the CDI after less than a year in the U.S. We confirmed that their rate of acquisition depends in part upon their age; older preschoolers learn faster. However, there were also small differences in the two populations that we tested. Children from Russia learned language somewhat more slowly than children from China and were reported to have passed fewer developmental milestones for their age. This could reflect differences in the social conditions that lead children to be put up for adoption in the two countries (and their medical and genetic correlates), but it might also reflect the differences in the gender distribution of the two samples and in the level of education of the adoptive mothers. The acquisition of time words was accelerated in preschool adoptees in both the younger group and the older group confirming the finding from our previous longitudinal study. Finally, like infants the preschoolers showed a tight synchronization between lexical and grammatical development, which was apparent both in the sentence complexity scale and in the parent's report of the child's longest utterances.

However, we also made a discovery which diverges from our previous findings. In both of our earlier studies, we found that the vocabulary composition of preschool adoptees tightly mirrored that of infant controls, with the only exceptions being words for time and adjectives for internal states. The present study complicates that picture. While the two and three years old adoptees went through the same shifts in vocabulary composition as the infants, these patterns were strongly attenuated in the older preschoolers. Nouns did not dominate their initial lexicon to the same degree, predicates came on strong from the onset of word learning and some children even appeared to show precocious acquisition of closed-class terms. These findings suggest that developmental effects on language acquisition during early childhood are more complex than our initial data suggested. But before drawing any strong conclusions from these findings, three issues had to be resolved.

First, we needed to rule out the possibility that these effects were driven by lexical differences in the input to infants and preschoolers. Nouns are lower in frequency and more variable across contexts, thus input differences would be expected to affect the acquisition of nouns more than verbs or closed-class items. The appendix reports a series of analyses that demonstrate that differences in frequency cannot account for these patterns. The frequency of the CDI words in the input to preschoolers is very similar to their frequency in the input to infants. When we remove terms that are low in frequency in the input to preschoolers, the critical findings are unaffected.

Next, we needed to ensure that this finding was replicable. In our prior studies, we observed no obvious differences between young preschoolers and older preschoolers. This could reflect the smaller sample size of those studies, differences in the statistical analyses, or the lack of systematic balancing for age of entry and time since adoption. However, it raises the possibility that the present findings are a fluke. To check this, in Study 2, we drew a second sample of adoptees from our pool of participants and conducted the same analyses.

Finally, if there are systematic differences between older adoptees and infants it raises the question of where these differences come from. One possibility is that older preschoolers, like school-aged children and adults, lean heavily on their first language in acquiring their second. If this is the case, then we might expect that Chinese adoptees and Russian adoptees would vary in their approach to language acquisition. This possibility is tested in Study 3, where we create matched samples of Chinese and Russian adoptees on the basis of vocabulary size and compare these critical qualitative features of early language production.[2]

Study 2

Methods

53 adopted preschoolers and 53 infant controls were selected for this analysis. To acquire the sample for Study 1, we had amassed a set of 262 CDI's from 90 different internationally-adopted preschoolers who met the exclusionary criteria of the study. Some of these children were not eligible for the previous study either because their age of adoption was just below (2;1-2;4) or just above (5;7-5;9) our range or because they had been adopted from a country outside of our regions of interest. Other children had been excluded from the sample because their parents had not returned the ASQ or because the cell that they would fit into was already full. Finally, most of our families contributed several sets of data over the course of the first year, but because we were using a cross-sectional design and wished to limit the impact of individual children on our analyses, only one session had been selected for the analysis.

To find out whether the observed differences between older and younger preschoolers would replicate, we constructed a new sample from this data set. First, we removed all the sessions that were used in Study 1. For each child who had not been included in the first study, we selected a session for Study 2 subject to the following constraints: 1) a vocabulary-matched control was

[2] We did not explore the effects of country of origin on vocabulary composition in Studies 1 and 2 for two reasons. First, the discovery that younger preschoolers differed from older preschoolers suggested that it would be necessary to look at the effects of country within each age group, severely limiting our power. Second, in these studies the Russian and Chinese children were not matched for their vocabulary size. Preliminary analyses demonstrated that spurious effects emerged in comparing unmatched samples. For example in Study 2, we found differences between the infant controls who were matched to the Russian preschoolers and the infant controls who were matched to the Chinese preschoolers. Since these two groups were pulled from the same population, based solely on their vocabulary size, this suggests that these analyses are disrupted by differences in the distribution of vocabulary sizes across groups. Many of the critical patterns in lexical composition are most apparent in a narrow vocabulary range (e.g., noun proportion peaks sharply between 150-250 words), thus their magnitude can be influenced by the number of children within that critical range. For this reason, all subsequent analyses focused on comparisons between groups of children who were tightly matched in this respect.

available; 2) when more than one session was available the earliest session was used. The second criterion was to ensure that we gained new data points at the earliest stages of lexical development when vocabulary composition is most variable. For those children who had contributed a session to the previous analysis, but had other sessions available, we selected a CDI that was as far apart as possible from the session that had been used in the previous analysis (M = 214 words apart). Thus children who contributed to the early portion of the acquisition curves in Study1, contributed to the later portion of these curves in Study 2.

The adoptees were matched to monolingual infant controls who had not been adopted. Each control had a CDI vocabulary that was within 6% or 25 words of the target child's vocabulary. The controls were drawn from a set of 119 sessions contributed by 100 children with the following constraints: all sessions used in Study 1 were removed and whenever possible a control who had not contributed a session to the first analysis was selected.

The final preschool group included 27 new children and 26 children who had contributed data to Study 1. The older preschool group consisted of 18 children, 10 from China (5 new) and 8 from Russia (3 new). Their ages ranged from 3;10 to 5;9 (M = 4;10) and they had been in the U.S. for an average of 8 months. The younger preschool group included 35 children, 19 from China (10 new), 1 from Korea and 15 from Russia (8 new). Their ages ranged from 2;1 to 3;9 (M = 2;11) and they had been in the U.S. for an average of 7 months. The infant control group included a total of 53 children (49 new) with a current age between 1;4 to 2;9 (M = 2;0).

The families participated in the data collection process described under Study 1. All families provided a background questionnaire and a completed CDI. Some also completed an ASQ and/or returned a videotape.

Results & Discussion

Our analyses focused on the lexical composition measures from the CDI.[3] The first series of regressions examined the effects of vocabulary-size measures and age group (infant control vs. preschool adoptee) in the full data set. We followed the analytic procedure described in Study 1. For all word types, there were robust effects of vocabulary size (R^2 = .653 to .297, all p's < .005). As in Study 1, age group (and its interactions with vocabulary) had no effects on the social word proportion (incremental R^2 = .005, p > .1), but reliable effects on nouns, predicates and time words (incremental R^2 = .101, p < .005; R^2 = .053, p < .005; R^2 = .109, p < .005 respectively). In contrast with Study 1, there were no effects of age group on closed-class words (incremental R^2 = .000, p > .1).

Tables 7 & 8 about here

To understand the source of the age effects, we split the sample in two and conducted a separate series of regressions on the younger preschoolers (and their controls) and another on the older preschoolers (and their controls). Again, these findings largely confirmed the results of Study 1 (see Tables 7 & 8). This is illustrated in Figures 3 to 7, in which the data for Study 2 appears underneath the parallel data from Study 1. For time words, there was a robust difference between both groups of preschoolers and their controls, with preschoolers knowing more words for time across the range of vocabulary sizes (Figure 7). The younger preschoolers were similar

[3] Vocabulary growth rate was not analyzed in this sample because sessions had been selected in part on the basis of vocabulary size which might create artifacts in this measure. The relation between sentence complexity and vocabulary size was not analyzed because the Study 2 sample was not balanced for the number of sessions that the children had participated in (preschoolers, particularly the younger ones, had participated in more session than infants). Prior research suggests that repeated sampling results in a small but discernable rightward shift in the sentence-complexity curve, presumably because parents remember more words if they have frequent exposure to the list (Bates & Goodman, 1997). However, repeated sampling does not have discernable affects on vocabulary composition (V. Marchman, personal communication). Both effects were verified in our data set by comparing a subset of infants adopted from China who differed in the number of sessions they had participated in but were matched for vocabulary size.

to their controls in all other respects: their early vocabularies were filled with social routines, nouns increased rapidly until 200 words and then declined, predicates experienced steady growth throughout this period, and the proportion of closed-class words began to grow at around 300 words. In each of these cases there was no reliable effect of age group and the variance that was accounted for when the age group variables were forced to enter the model was quite small (all incremental R^2's < .04, all p's > .1).

In contrast, the lexical composition of the older preschoolers differed from their controls in two critical respects. First, as in Study 1, the older preschoolers initially learned fewer nouns than the infant controls and thus have a lower peak and a more gradual descent to the baseline value of the checklist (Figure 4). The effects of age group were quite strong; when these factors were added to the regression model that already contained the vocabulary size predictors, the proportion of variance that was accounted for tripled. Second, the shift in the noun trajectory was accompanied by changes in the trajectory of predicates. Just as in Study 1, the older preschoolers learned many of these words early in lexical development. In infants the proportion of predicates tripled as vocabulary size increased from 20 to 600 words, in older preschoolers it essentially stayed constant.

In contrast with Study 1, there were no effects of age group on social words in the older half of the sample. This was not surprising: as we noted, the effect in Study 1 was driven largely by a single data point and was small in magnitude. Finally, we found no difference between the older preschoolers and their controls in the acquisition of closed-class words in this sample (Figure 6). In Study 1, this effect was fairly large (incremental $R^2 = .163$) and was not attributable to any small set of data points. However, in all groups, the proportion of closed-class words was variable and not strongly correlated with vocabulary size. Consequently, small differences between populations would be expected to emerge and disappear in studies with a moderate sample sizes.

In sum, the basic pattern of effects that we observed in Study 1 is robust. Children who begin acquiring English at four or five years old show systematic deviations from the vocabulary composition trajectories that characterize early development in infants and young preschoolers. Next, we explored whether these deviations were shaped by the birth language of the child.

Study 3

Methods

Thirty-nine preschoolers who were adopted from China and 39 preschoolers who were adopted from Russia were selected for this analysis. For each country of origin there were 20 children who had been adopted as younger preschoolers and 19 who had been adopted as older preschoolers. This sample was selected from the full set of 262 CDI's that had been collected and was constructed by taking each Russian adoptee and attempting to match him or her to a Chinese adoptee from the same half of the sample (younger vs. older preschooler) who had a similar vocabulary size (±10% or 25 words). Where multiple sessions could be selected, we chose ones in which the child's vocabulary size was under 500 words and which had not been used in a previous analysis. All of the participants had been included in the sample for Study 1, Study 2, or both. No infant controls were used.

The older group of Russian adoptees had been adopted between the ages of 3;10 and 5;9 (M = 4;10) and had been in the U.S. for an average of 7 months. The matched group of older Chinese adoptees was 3;11 to 5;6 (M = 4;9) at the time of adoption and had been in the U.S. for an average of 7 months. The younger preschoolers from Russia were adopted between 2;5 to

3;8 (M = 2;11) and had been in the U.S. for an average of 8 months. The younger preschoolers from China were 2;5 to 3;7 (M = 3;0) at adoption and were tested an average 8 months later.

Results & Discussion

Vocabulary Composition

The first series of regressions examined the effects of vocabulary size and country of origin in the full data set. In all of these analyses, there were robust effects of vocabulary size (R^2 = .833 to .177, all p's < .005) confirming that there are systematic shifts in the vocabulary composition of preschool learners during this period of acquisition. However, country of origin did not have reliable effects in any of these analyses (all incremental R^2's < .05, p > .1).

Table 9 & 10 about here

To explore whether there might be effects of country of origin that are limited to older preschoolers, we split the younger and older groups and conducted separate regressions (Tables 9 & 10). In the younger preschoolers, there were very large effects of vocabulary size on the proportion of nouns, verbs and closed-class words in the child's lexicon. The effects of vocabulary size were considerably smaller in the older preschoolers, confirming our previous findings.[4] In the younger group, none of the effects of country of origin were reliable. But critically, in the older children country of origin had a moderate and reliable effect on the predicate proportion. Figures 10 – 12 illustrate these effects for three dependent variables that were consistently affected by the age of the learner in Studies 1 and 2.

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[4] These differences between younger and older preschoolers were reliable, resulting in large effects of half of sample in an additional analysis of the full data set (incremental R^2 = .081 to .346, all p's < .05)

Figures 10 -12 about here

Figure 10 graphs the noun proportion in younger and older preschoolers. As in the previous studies the curve for the younger children has the high peak that characterizes infant language learning, while the growth curve for preschoolers is much flatter. However this difference appears to be present in both the children from China and the children from Russia (with one exception) suggesting that whatever causes it is consistent across both groups. Given that children in both linguistic groups are likely to have had substantial experience acquiring nouns, this is not surprising.

The predicate proportion for each group is shown in Figure 11. Again, we see a striking difference between the younger and older preschoolers. The younger children show the steady growth in predicates that occurs in infant language learning. The older children have much flatter acquisition curves. In this case, there is also an effect of country of origin. While the proportion of predicates for Russian adoptees grows a little over time, the children with China start out high and show no increase. This difference between the two groups is highly variable across children particularly in the early stages of development, suggesting that while the effect is statistically significant, it may not be a stable feature of acquisition in these two populations.

Finally, Figure 12 graphs the time word proportion. Here the younger and older preschoolers appear to be quite similar to one another and different from infant learners. The scatter plots and analyses suggest that whatever advantage the preschoolers have in learning time words is equally shared by the younger and older preschoolers and by the children from China and those from Russia.

Lexical –Grammatical Synchrony

Parallel regression analyses on the sentence complexity scores confirmed that utterance complexity is tightly correlated with vocabulary size. This function is completely unaffected by the child's country of origin (incremental R^2's < .003) and is closely parallel in the younger and older preschoolers.

General Discussion

These results confirm four of the findings from our previous studies. First, preschool language learners show accelerated acquisition of temporal terms, suggesting that there are developmental roadblocks that hinder the acquisition of these words in younger children (see Snedeker et al., in press for discussion). Second, older children learn faster than younger children who are similarly situated: our preschoolers outpaced typically developing infants and the older preschoolers outpaced the younger ones. Third, with the exception of temporal terms, children who were adopted between the ages of 2;5 and 3;9 showed the same shifts in lexical composition as infant language learners. Fourth, all of the groups of preschool learners showed the same systematic relation between lexical and grammatical development that characterizes typical infant learners. This was true not only for the sentence complexity metric but also for the measure of utterance length based on the parental report of the child's longest sentences.

But these studies also resulted in three new discoveries. First, we found that there were large and persistent differences in lexical composition between children who began acquiring English between 2;5 and 3;9 (three-year-olds) and those who began between 3;10 and 5;6 (five-year-olds). In the five-year-olds, the typical developmental shifts were attenuated. Predicates appeared early, nouns never really dominated, and there was some evidence suggesting that closed-class words were acquired precociously. Second, most of these patterns were unaffected by the child's country of origin suggesting that transfer between the child's first and second language was limited, or had similar effects on the children who had learned Chinese and those who had learned Russian.

In the remainder of this discussion we explore four questions raised by this data pattern. How do the new findings bear on the developmental hypothesis? What might account for the differences that we observed between the lexical development of the five-year-olds and that of the three-year-olds? What role is the child's birth language playing in these changes?

Evaluating the developmental hypothesis

The present data suggest that the effects of cognitive development on language acquisition in early childhood are more complex than our previous data had suggested. While three-year-old learners show the same shifts in lexical composition as infants, five-year-olds do not. At first glance these findings may appear to be compatible with a developmental hypothesis for shifts in lexical composition: with sufficient cognitive resources the child can overcome whatever hurdles hinder the acquisition of predicates in the early stages of typical acquisition. However, this interpretation cannot explain how typically-developing infants overcome these hurdles. If it requires the cognitive skills of a five-year-old to develop a lexicon with a more proportional representation of nouns and verbs, then typically-developing children should not master this feat until kindergarten. In actuality, all the changes that we studied typically occur between about 16 and 30 months of age.

Thus the most relevant population for testing the developmental hypothesis is learners who are just a little bit more mature than first language learners who are solving these problems (but reliably more mature). Our young preschoolers provide precisely the right comparison. As the ASQ analyses demonstrated, these learners are more cognitively sophisticated than the infant learners. Our previous longitudinal study suggests that most of these children probably produced

4-5 word utterances in their native language at the time they began learning English (Snedeker et al., in press). Thus they clearly possess any cognitive prerequisites to learning a diverse set of lexical items. Nevertheless, they show the same pattern of changes in lexical composition as infant learners. Thus cognitive development or maturation cannot account for these qualitative shifts. Instead it is likely that the early acquisition of nouns is fueled by the child's ability to quickly identify the referents of nouns on the basis of social cues and visual context, while the slow acquisition of predicates and closed-class items reflects the need to use linguistic cues (such as the nouns or syntactic context) to acquire these terms (Gillette et al., 1999; Gleitman, 1990). Until the child masters many nouns and learns the syntactic structures of her new language, the development of relational and grammatical words will lag behind.

The current studies also addressed developmental hypotheses about the relation between syntax and lexical development. Here the results were simple and consistent, with all groups showing the same pattern of lexical-grammatical synchrony. This is consistent with research on a variety of populations, including early simultaneous bilinguals (Conboy & Thal, 2006; Marchman, Martínez-Sussmann, & Dale, 2004). The persistence of this pattern in older children suggests that there are strong causal links between lexical development and growth in the complexity of children's utterances which are not attributable to rate-limiting development in some other domain.

However, the fact that the pattern persists even when vocabulary acquisition is atypical raises questions about what the nature of these connections might be. Four possibilities are typically proposed (Bates & Goodman, 1997). The correlations could reflect: 1) the use of emerging grammatical abilities to learn words (Gleitman, 1990), 2) the dependence of syntactic acquisition on an understanding of lexical content (e.g, Pinker, 1984), or 3) the use of lexically-specific combinatorial operations in a period before abstract syntactic categories develop (Tomasello, 1992). We believe that all of these proposals, have one thing in common: the relation between lexical development and syntax should be specific (or at least stronger) for some classes of words than others. On Gleitman's hypothesis it should be the acquisition of verbs and other relational terms that depends on prior syntactic development. In contrast, if knowing the meanings of words is critical to discovering syntactic rules (Pinker, 1984), then the acquisition of the lexical classes that are pivotal to discovering these rules (such as verbs) should be particularly important. Finally, on Tomasello's hypothesis, nouns play little role in structuring early utterances; in the verb-island stage,predicates guide combinatorial speech. Thus it appears that all of these theories would predict that sentence complexity would be linked to predicate knowledge. Because older children are acquiring this knowledge at an earlier vocabulary size, we would expect that there complexity curves would be shifted to the left. But they are not. Thus our data present another mystery to be solved.

Why do five-year-olds learn more predicates and fewer nouns?

The five-year-old children in this study broke into word learning in a very different way than either the infants or the three-year-olds. They learned a more diverse set of words and thus acquired proportionally fewer nouns and more predicates (and perhaps more closed-class terms). These differences are particularly interesting because they occur in a learning context with few of the confounding factors that typically plague research on early second-language acquisition. The differences occurred despite the fact that the three-year-olds and five-year-olds were receiving similar input, in a similar social context, and had begun acquiring the same birth languages. The prior literature offers several different ways of viewing these differences.

Inspired by Meisel's hypothesis for an early critical period in syntactic development (2009), one could argue that these data suggest that there is a critical period of sorts for lexical learning. At some point in maturation children lose access to the implicit processes by which they typically acquire words and are forced to use other mechanisms which have different processing signatures. The current data do not provide compelling support for this hypothesis. It is not clear that the five-year-olds are using a different or a poorer method for acquiring words than the three-year-olds. In fact, whatever they are doing allows them to acquire a greater variety of words in a shorter period of time. Thus there is no reason to conceive of this developmental change as the loss of an ability (or decline in neural or cognitive flexibility).

Second, these differences could reflect the use of cognitive and linguistic skills that are unavailable to the younger preschoolers. For example, the five-year-olds may be using their greater metalinguistic abilities to seek out translation equivalents to words that they had learned in their first language. Or they may have the ability to better remember and compare utterances. Of course these hypotheses are not mutually exclusive. The very cognitive skills that help five-year-olds learn words could lead them analyze the input in ways that may impede their morphosyntactic development (Newport, 1990). While our data provides no evidence that this is occurring, our measures (utterance length and performance on the sentence complexity metric) were quite coarse. Our ongoing work explores a richer set of syntactic phenomena using the speech samples that we collected for these studies.

How does birth language influence early acquisition?

One of the primary goals of this study was to find out whether differences in the children's birth language had any effect on their acquisition of English. There is ample evidence that second-language acquisition in adults and older children is strongly shaped by the learners' first language. Transfer effects occur in all domains of language from speech perception and production to syntax (see e.g., Dupoux, Kazehi, Hirose, Pallier & Mehler, 1999; Eckman, Elreyes & Iverson, 2003; White, 1985).[5] Thus we might expect to see such effects in internationally-adopted preschoolers. Three kinds of transfer effects might plausibly have emerged in these analyses. First, we might have expected children from Russia to show more advanced acquisition of closed-class morphemes resulting in higher sentence complexity scores. Russian is an inflectionally rich language that morphologically marks tense, aspect and case (Comrie, 1990). Many of these forms are acquired early and thus might have provided the adopted children with a template for acquiring the more limited inflectional system of English (Smoczynska, 1985; Weist & Witkowska-Stadnik, 1986). In contrast Mandarin and Cantonese have no inflectional morphology and few function words (Comrie, 1990). However, there were no differences between the children from China and Russian in the acquisition of closed-class words or the development of sentence complexity.

Second, because Chinese languages do not morphologically mark tense, the communication of tense distinctions requires the use of open class items like the time words on the CDI. Consequently, we might have expected that the accelerated acquisition of temporal terms would be greater in children from China, but no such effect appeared.

Finally, Chinese languages have properties that may facilitate the acquisition of predicates: the lack of inflectional morphology simplifies the form to meaning mapping, the permissibility of dropping subjects and objects results allow verbs to appear often in perceptually salient positions, and the use of many semantically heavy verbs may make it easier for children to learn

[5] The word "transfer" is rarely used in the second-language acquisition literature because it is associated with theories that posit a shallow representational basis for such phenomena (copying of surface structures or individual items). However, the transfer of more abstract knowledge (e.g., parameter settings or constraint rankings) pervades contemporary theories (see Glass, 1996 for historical discussion in the domain of syntax).

their meanings (Tardif, Shatz & Naigles, 1997). Children acquiring Mandarin or Cantonese learn more verbs in the early stages of acquisition than children learning English, or most other European languages (Tardif, Gelman & Xu, 1999). Thus we might expect that children from China would begin acquiring English with knowledge of more verbs and perhaps with better strategies for acquiring them, leading them to succeed at this task at an earlier age. This prediction receives some support in Study 3. In the older preschool group, the children from China have a small but reliable advantage in acquiring predicates.

But by and large we find little evidence for cross-linguistic transfer in the preschool learners. In the case of the three-year-olds, this is consistent with the claim that they are acquiring English in much the same way as an infant. In the case of the five-year-olds, it is more puzzling. Our findings are consistent with three possibilities. First, the maturational changes that shape lexical development in five-year-olds may not be ones that promote cross-linguistic transfer during acquisition. For example the acquisition of predicates might be helped along by domain-general cognitive processes. Second, children may be transferring knowledge from their birth language but the relevant knowledge might be equivalent in both languages. For example, both groups of children might be using the verbs they know from their birth language to acquire English verbs, but Russian and Mandarin might be equally helpful in this respect. Finally, there may be more specific patterns of cross-linguistic transfer which do vary across the two language groups but were not assessed in these studies.

The end of the beginning and the beginning of the end

These studies explored how developmental changes between the ages of one and five years might shape language acquisition. Lenneberg proposed that a biological capacity for language matured over the first three years of life, accounting for the gradual emergence of linguistic abilities (Lenneberg, 1967). We investigated this possibility by comparing children who begin acquiring a new language at the end of this period, to young infants who start the process at the beginning of this period. Our findings suggest that this facet of the critical period hypothesis is wrong. Three-year-old children go though many of the same stages in acquiring a language as infants do.

So when does this period of infant like acquisition end? Our results suggest that the beginning of the end may come as early as four or five years of age. However, it is too early to know whether the differences that we observed in early lexical composition have any bearing on the decline in ultimate attainment observed in second-language learners during the school years (Flege et al., 1999; Johnson & Newport, 1989) or reports of an early critical period for the acquisition of inflection (Meisel, 2009).

Appendix: Can differences in input frequency account for the shift in vocabulary composition in the older preschoolers?

The token frequency of different words varies systematically across syntactic categories (see e.g., Johansson & Hoffland, 1989). Closed-class items are highly frequent and stable across contexts; we use the same determiners, auxiliaries, prepositions, pronouns, and quantifier regardless of the topic at hand. The token frequency of verb types is quite variable. However, the most common verbs, many of which appear on the CDI, are both frequent and ubiquitous (Sandhofer, Smith & Luo, 2000) because they have semantically bleached meanings (e.g., *give*, *get*, *look*) which allow them to appear across a variety of contexts. In contrast, most noun types are quite low in frequency and often used in very limited contexts (e.g., *pumpkin*, *snow*, *crib*).

These differences could impact the older learners in two ways. First, because the words on the CDI were selected to assess infant language acquisition, they may not reflect the words that are commonly heard (or learned) by children who encounter the language at an older age. Thus the CDI might underestimate the vocabulary size of older learners. Because nouns are less stable across contexts, preschoolers' performance on these terms could be impacted to a greater degree than closed-class items or predicates. Both older and younger children encounter words like *over*, *go,* and *blue*, but it is possible that only infants are hearing words like *diaper*, *crib* and *boo boo.* Second, the older preschoolers are learning their first words far more rapidly than infants (see Snedeker et al., in press) and somewhat more rapidly than younger preschoolers (see Study 1). Because the set of nouns that speakers use is less stable across situations, children may simply fail to run into many of these words until they reach a higher vocabulary level. For example, an older adoptee might be less likely to acquire nouns like *pumpkin*, *snowman* and *mittens* at a low vocabulary level because she arrived in the spring and acquired 500 words before Halloween rolled around. To explore these possibilities, we conducted two analyses.

First, we searched the CHILDES corpora to determine the frequency of the words on the CDI both in speech to infants and in speech to preschoolers. Transcripts were included in the analysis if: 1) they were in the U.S. English corpora on CHILDES; 2) they had the target child marked as *CHI (to allow us to check tiers of speech for speakers other than *CHI) and 3) if information on the age of the child in the transcript was readily available (either from the CHILDES manual or other sources). Transcripts were grouped by age of the target child, with one group for children under 2;6, and another for children between 2;6 and 6;0. There were 1,049 transcripts analyzed for children under 2;6 (2.2 million words of child-directed speech) and 1,067 for children over 2;6 (2.6 million words of child-directed speech).

The frequency of CDI words was obtained using FREQ and FREQMERG. The CDI vocabulary measure contains 680 items, 59 of these items were excluded from our analysis for one of three reasons: 1) the item did not provide a stable search string (e.g., "child's own name"); 2) the item consisted of more than one word (e.g., "on top of"); 3) the word was ambiguous and if the other meaning of the word was frequent in the corpora.[6] For the remaining 621 CDI words, totals were determined by using FREQ to search for the root word and all relevant inflected forms (e.g., plural or past tense) and common diminutives (e.g., *doggie* for *dog*). The raw frequency of each word in the infant corpora was highly correlated with its raw frequency in the preschool corpora ($R^2 = .97$, $p < .001$). Because word frequency follows a

[6] Specifically, if a word appeared on the CDI with more than one meaning (e.g., *chicken* as food and *chicken* as an animal) or if the coder noted that it had two frequent meanings that were unrelated or belonged to different syntactic categories, then ten instances of this word were sampled from at least two transcripts. These ten instances were coded by hand. If the word was used 70% or more of the time with one meaning, then that word was included in the analysis and the total count was assigned to that meaning. If it was used as one part of speech 60% of the time or less, it was excluded from analysis.

Zipfian distribution, the relation between two corpora is more accurately captured by comparing them on a log-log scale (Zipf, 1935). On the log-log scale the correlation between the infant and preschool corpora continues to be highly robust ($R^2 = .87$, $p < .001$). The residual variance in this analysis is primarily contributed by words that have a low raw frequency in both corpora. This could reflect differences in the use of these lower-frequency words with children of different ages, or it could be a side effect of the increase in noise that occurs in estimates of log frequency as the number of expected instances decreases (Baayen, 2001).

Second, to explore whether input differences for low frequency words might have contributed to the effects that were observed in Study 1, we removed these words and reanalyzed our data. Specifically, all words whose natural log frequency in the preschool corpora was less than 5 were deleted from the CDI data set for Study 1 (these are words that occur less than 57 times per million words of speech directed at preschoolers). Vocabulary size and composition was recalculated for each participant and the analyses described in Study 1 were conducted using these new values. The central findings persisted and the size of the effects was quite similar to the original analyses. More precisely, the younger preschoolers differed from their controls only the proportion of time words in their lexicon ($R^2 = .190$ in Experiment 1, $R^2 = .160$ in the restricted analysis), while the older preschoolers differed in their controls for nouns, predicates, closed-class words and time words ($R^2 = .323$ vs. $R^2 =.316$; $R^2 = .262$ vs. $R^2 =.201$; $R^2 = .163$ vs. $R^2 =.105$; and $R^2 = .175$ vs. $R^2 =.142$, respectively). The only effect that did not replicate in the restricted analysis was the difference in the acquisition of social words that was observed in Study 1, suggesting again that this difference might be artifactual.

In addition to these analyses, two arguments suggest that frequency differences between nouns and other words cannot account for our findings. First, the frequency hypothesis predicts that younger preschoolers should either pattern with older preschoolers or be intermediate between the infant learners and the older preschool group. Specifically, the pace of learning in the younger preschoolers is more similar to older preschoolers than it is to infants. At 18 months of age, about six months after word learning begins in earnest, the average infant has a CDI vocabulary of around 100 words (Fenson et al., 1994). Six months after adoption our younger preschoolers have amassed an average 330 words, while the older ones have acquired about 450. Similarly, like older children, the younger preschoolers are unlikely to wear diapers, sleep in cribs, or use high chairs, and thus they might be delayed in learning those words. Nevertheless, with the exception of time words, they showed the same acquisition patterns as infants and starkly different patterns than the older preschool group, resulting in reliable interactions (see Table 4).

Second, on the frequency hypothesis we would expect a disruption in lexical-grammatical synchrony in the older preschoolers. On this account, older preschoolers appear to have a different lexical composition than younger learners because we are systematically underestimating their vocabulary size (specifically the number of nouns that they know). If the older children are really more lexically advanced than their CDI vocabulary score would suggest, then we might expect their sentence complexity scores to be higher than the controls, since presumably their grammatical development should reflect their true vocabulary and not our misestimate. However, we found that the grammatical abilities of the older children were linked to their CDI vocabulary in precisely the same way as the younger children. We conclude that the observed differences in vocabulary composition are not merely a side effect of input differences or an artifact of our measures. They warrant a real explanation.

Authors Note

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Table 1: Age and time since adoption for Study 1 sample.

		Age of Adoption (years)			Time since Adoption at Test (months)			Age at Test (years)		
		M	SD	range	M	SD	range	M	SD	range
Chinese Preschoolers	Younger	3;0	.38	2;7-3;9	6.42	4.08	0-12	3;7	.42	2;10-4;4
	Older	4;8	.36	3;11-5;1	6.33	3.50	2-11	5;3	.46	4;6-5;10
	Total	3;10	.94	--	6.4	3.70	--	4;4	0.94	--
Russian Preschoolers	Younger	2;11	.29	2;5-3;6	6.58	3.99	1-12	3;6	.48	2;7-4;3
	Older	4;11	.58	3;10-5;6	6.75	3.33	2-12	5;6	.52	4;9-6;3
	Total	3;11	1.11	--	6.7	3.6	--	4;6	1.14	--
Chinese Infants		1;0	0.15	0;8-1;3	13.88	4.5	4-20	2;2	0.41	1;4-2;10
Unadopted Infants		n/a	n/a	n/a	n/a	n/a	n/a	2;0	0.36	1;5-2;8

Table 2: Demographic information and developmental concerns for Study 1 sample.

	Female	Maternal Education*	Believed delayed in birth language	Never or rarely exposed to birth language	No or Little concern about child's language	Hearing Impairment**	Diagnosed Developmental Delay			
							Attention	Gross Motor	Fine Motor	Social
Chinese Preschoolers	75%	M = 3.54	9%	88%	71%	13%	0%	4%	0%	0%
Russian Preschoolers	54%	M =3.29	70%	79%	71%	13%	8%	21%	13%	17%
Chinese Infants	100%	M = 3.54	0%	92%	100%	4%	0%	13%	0%	0%
Unadopted Infants	46%	M = 3.71	n/a	n/a	100%	4%	0%	4%	0%	0%

* Maternal education: high school (1), some college (2), college graduate (3), graduate or professional degree (4).
** Hearing impairments had been resolved at the time of data collection for all participants except the one unadopted infant. No participant was known to have had bilateral hearing loss.

Table 3: Study 1, regression models for effects of vocabulary size and age group (infant control or preschool adoptee) on vocabulary composition and sentence complexity.

	CDI Vocabulary Size			Age Group (Preschooler = 1, Infant = 0)		
Measure	**Total Variance**	**Predictors**	**β in final model**	**Total Additional Variance**	**Predictors**	**β in final model**
Social Words	R^2 = .754	intercept	37.24**	R^2 = .009	age group	ns
		vocab size	-0.122**		age x vocab	ns
		$vocab^2$	1.34E-04**		age x $vocab^2$	ns
Nouns	R^2 = .359	intercept	37.82**	R^2 = .103	age group	ns
		vocab < 200	.103**		age x vocab < 200	-2.23E-2**
		vocab > 200	-3.86E-2**		age x vocab > 200	ns
Predicates	R^2 = .564	intercept	8.91**	R^2 = .054	age group	5.95**
		vocab size	3.28E-2**		age x vocab	-9.90E-3*
Closed Class	R^2 = .317	intercept	5.01**	R^2 = .074	age group	2.07**
		vocab > 300	1.99E-2**		age x vocab	ns
Time Words	R^2 = .379	intercept	-.222	R^2 = .174	age group	.615**
		vocab size	2.53E-3**		age x vocab	ns
Sentence Complexity	R^2 = .705	intercept	.425	R^2 = .003	age group	ns
		vocab > 200	6.43E-2**		age x vocab > 200	ns

Vocabulary size predictors were added in step 1 and total variance was calculated. Age group and its interactions with vocabulary size were added in step 2 and additional variance was calculated. Finally, a backward regression was conducted to determine which predictors were reliable and calculate the β coefficients in the final model. Asterisks indicate p-values in the final model (* < .05, ** < .005).

Table 4: Study 1, backward regression models comparing the effects of age group, half of sample, and their interaction. Presence of the interaction suggests that differences between infant and preschooler learners may be limited to children adopted after 3;9.

	Age Group (1 = Adopted Preschoolers, 0 = Infant Controls)			Half of Sample (1=Older Adoptees & Controls, 0=Younger Adoptees & Controls)			Age Group * Half of Sample (1 = Older Adoptees, 0 = All Others)		
Measure	**Added Variance** (after vocab size)	**Predictors**	**β in final model**	**Added Variance** (after vocab size)	**Predictors**	**β in final model**	**Added Variance** (after vocab size)	**Predictors**	**β in final model**
Social Words	R^2 = .009	age group	ns	R^2 = .019	half of sample	ns	R^2 = .032	age * half	-12.45**
		age * vocab	ns		half * vocab	ns		age * half * vocab	8.50E-2**
		age * vocab2	ns		half * vocab2	ns		age * half * vocab2	-1.20E-4**
Nouns	R^2 = .103	age group	ns	R^2 = .019	half of sample	ns	R^2 = .149	age * half	-9.12**
		age * vocab < 200	-1.55E-2*		half * vocab < 200	ns		age * half * vocab < 200	ns
		age * vocab > 200	ns		half * vocab > 200	ns		age * half * vocab > 200	2.84E-2**
Predicates	R^2 = .054	age group	ns	R^2 = .009	half of sample	-2.09*	R^2 = .103	age * half	12.85**
		age * vocab	ns		half * vocab	ns		age * half * vocab	-2.17E-2**
Closed Class	R^2 = .074	age group	ns	R^2 = .008	half of sample	ns	R^2 = .075	age * half	2.44**
		age * vocab > 300	ns		half * vocab > 300	ns		age * half * vocab > 300	ns
Time Words	R^2 = .174	age group	.615**	R^2 = .010	half of sample	ns	R^2 = .094	age * half	ns
		age * vocab	ns		half * vocab	ns		age * half * vocab	ns
Sentence Complexity	R^2 = .003	age group	ns	R^2 = .001	half of sample	ns	R^2 = .008	age * half	ns
		age * vocab > 200	ns		half * vocab > 200	ns		age * half * vocab > 200	ns

Each set of factors was added separately to a model which contained the vocabulary size predictors (Table 1) to calculate additional variance. Next, a backward regression was conducted with all factors to determine which predictors were reliable and calculate the β coefficients in the final model. Asterisks indicate p-values in the final model (* < .05, ** < .005).

Table 5: Study 1, regression models comparing younger preschoolers (age of adoption 2;5 to 3;9) to infant controls.

	CDI Vocabulary Size			Age Group (Preschooler = 1, Infant = 0)		
Measure	**Total Variance**	**Predictors**	**β in final model**	**Total Additional Variance**	**Predictors**	**β in final model**
Social Words	R^2 = .766	intercept	40.34**	R^2 = .000	age group	ns
		vocab size	-.150**		age x vocab	ns
		vocab2	1.79E-04**		age x vocab2	ns
Nouns	R^2 = .490	intercept	38.26**	R^2 = .025	age group	ns
		vocab < 200	9.85E-2**		age x vocab < 200	ns
		vocab > 200	-4.52E-2**		age x vocab > 200	ns
Predicates	R^2 = .651	intercept	10.66**	R^2 = .002	age group	ns
		vocab size	3.09E-2**		age x vocab	ns
Closed Class	R^2 = .294	intercept	5.71**	R^2 = .027	age group	ns
		vocab > 300	2.05E-2**		age x vocab	ns
Time Words	R^2 = .402	intercept	-.226	R^2 = .190	age group	.573**
		vocab size	2.41E-3**		age x vocab	ns
Sentence Complexity	R^2 = .631	intercept	.467	R^2 = .017	age group	ns
		vocab > 200	6.15E-2**		age x vocab > 200	ns

Vocabulary size predictors were added in step 1 and total variance was calculated. Age group and its interactions with vocabulary size were added in step 2 and additional variance was calculated. Finally, a backward regression was conducted to determine which predictors were reliable and calculate the β coefficients in the final model. Asterisks indicate p-values in the final model (* < .05, ** < .005).

Table 6: Study 1, regression models comparing older preschoolers (age of adoption 3;10 to 5;6) to infant controls.

	CDI Vocabulary Size			Age Group (Preschooler = 1, Infant = 0)		
Measure	**Total Variance**	**Predictors**	**β in final model**	**Total Additional Variance**	**Predictors**	**β in final model**
Social Words	R^2 = .781	intercept	38.91**	R^2 = .054	age group	-11.57**
		vocab size	-.128**		age x vocab	7.10E-2**
		vocab2	1.40E-4**		age x vocab2	-9.53E-5*
Nouns	R^2 = .236	intercept	42.59**	R^2 = .316	age group	-13.03**
		vocab < 200	9.18E-2**		age x vocab < 200	ns
		vocab > 200	-4.73E-2**		age x vocab > 200	2.94E-2*
Predicates	R^2 = .452	intercept	6.45**	R^2 = .262	age group	14.37**
		vocab size	3.68E-2**		age x vocab	-2.57E-2**
Closed Class	R^2 = .306	intercept	5.03**	R^2 = .163	age group	3.08**
		vocab > 300	1.83E-2**		age x vocab	ns
Time Words	R^2 = .333	intercept	-.168	R^2 = .175	age group	.659**
		vocab size	2.52E-3**		age x vocab	ns
Sentence Complexity	R^2 = .730	intercept	.623	R^2 = .017	age group	ns
		vocab > 200	6.52E-2**		age x vocab > 200	ns

Vocabulary size predictors were added in step 1 and total variance was calculated. Age group and its interactions with vocabulary size were added in step 2 and additional variance was calculated. Finally, a backward regression was conducted to determine which predictors were reliable and calculate the β coefficients in the final model. Asterisks indicate p-values in the final model (* < .05, ** < .005).

Table 7: Study 2, regression models comparing younger preschoolers (age of adoption 2;1 to 3;9) to infant controls.

	CDI Vocabulary Size			Age Group (Preschooler = 1, Infant = 0)		
Measure	**Total Variance**	**Predictors**	**β in final model**	**Total Additional Variance**	**Predictors**	**β in final model**
Social Words	R^2 = .678	intercept	46.09**	R^2 = .004	age group	ns
		vocab size	-.177**		age x vocab	ns
		vocab2	2.04E-4**		age x vocab2	ns
Nouns	R^2 = .345	intercept	38.91**	R^2 = .031	age group	ns
		vocab < 200	7.53E-2**		age x vocab < 200	ns
		vocab > 200	-3.03E-2**		age x vocab > 200	ns
Predicates	R^2 = .641	intercept	10.43**	R^2 = .025	age group	ns
		vocab size	3.03E-2**		age x vocab	ns
Closed Class	R^2 = .354	intercept	6.20**	R^2 = .007	age group	ns
		vocab > 300	2.02E-2**		age x vocab	ns
Time Words	R^2 = .421	intercept	-.111	R^2 = .078	age group	.384**
		vocab size	2.42E-3**		age x vocab	ns

Vocabulary size predictors were added in step 1 and total variance was calculated. Age group and its interactions with vocabulary size were added in step 2 and additional variance was calculated. Finally, a backward regression was conducted to determine which predictors were reliable and calculate the β coefficients in the final model. Asterisks indicate p-values in the final model (* < .05, ** < .005).

Table 8: Study 2, regression models comparing older preschoolers (age of adoption 3;10 to 5;9) to infant controls.

	CDI Vocabulary Size			Age Group (Preschooler = 1, Infant = 0)		
Measure	**Total Variance**	**Predictors**	**β in final model**	**Total Additional Variance**	**Predictors**	**β in final model**
Social Words	R^2 = .821	intercept	28.73**	R^2 = .006	age group	ns
		vocab size	-7.11E-2**		age x vocab	ns
		vocab2	6.83E-5**		age x vocab2	ns
Nouns	R^2 = .196	intercept	48.73**	R^2 = .419	age group	-12.57**
		vocab < 200	4.88E-2*		age x vocab < 200	ns
		vocab > 200	-3.87E-2**		age x vocab > 200	2.97E-2**
Predicates	R^2 = .371	intercept	10.35**	R^2 = .194	age group	10.11**
		vocab size	2.83E-2**		age x vocab	-1.64E-2*
Closed Class	R^2 = .396	intercept	6.21**	R^2 = .059	age group	ns
		vocab > 300	1.75E-2**		age x vocab	ns
Time Words	R^2 = .453	intercept	-.423	R^2 = .180	age group	.686**
		vocab size	3.26E-3**		age x vocab	ns

Vocabulary size predictors were added in step 1 and total variance was calculated. Age group and its interactions with vocabulary size were added in step 2 and additional variance was calculated. Finally, a backward regression was conducted to determine which predictors were reliable and calculate the β coefficients in the final model. Asterisks indicate p-values in the final model (* < .05, ** < .005).

Table 9: Study 3, regression models for effects of country of origin in younger preschoolers (age of adoption 2;5 to 3;9).

	CDI Vocabulary Size			Country (Russia = 1, China = 0)		
Measure	**Total Variance**	**Predictors**	**β in final model**	**Total Additional Variance**	**Predictors**	**β in final model**
Social Words	R^2 = .839	intercept	33.48**	R^2 = .002	country	ns
		vocab size	-.105**		country x vocab	ns
		vocab^2	1.15E-4**		country x vocab^2	ns
Nouns	R^2 = .626	intercept	36.27**	R^2 = .046	country	ns
		vocab < 200	.102**		country x vocab < 200	ns
		vocab > 200	-4.20E-2**		country x vocab > 200	ns
Predicates	R^2 = .502	intercept	14.39**	R^2 = .043	country	ns
		vocab size	2.24E-2**		country x vocab	ns
Closed Class	R^2 = .480	intercept	5.33**	R^2 = .007	country	ns
		vocab > 300	2.47E-2**		country x vocab	ns
Time Words	R^2 = .194	intercept	.723**	R^2 = .008	country	ns
		vocab size	1.63E-3*		country x vocab	ns
Sentence Complexity	R^2 = .714	intercept	2.18	R^2 = .002	country	ns
		vocab > 200	6.30E-2**		country x vocab > 200	ns

Vocabulary size predictors were added in step 1 and total variance was calculated. Country of origin and its interactions with vocabulary size were added in step 2 and additional variance was calculated. Finally, a backward regression was conducted to determine which predictors were reliable and calculate the β coefficients in the final model. Asterisks indicate p-values in the final model (* < .05, ** < .005).

Table 10: Study 3, regression models for effects of country of origin in older preschoolers (age of adoption 3;10 to 5;9).

	CDI Vocabulary Size			Country (Russia = 1, China = 0)		
Measure	**Total Variance**	**Predictors**	**β in final model**	**Total Additional Variance**	**Predictors**	**β in final model**
Social Words	R^2 = .847	intercept	28.22**	R^2 = .002	country	ns
		vocab size	-6.70E-2**		country x vocab	ns
		$vocab^2$	6.21E-5**		country x $vocab^2$	ns
Nouns	R^2 = .507	intercept	12.24*	R^2 = .020	country	ns
		vocab < 200	.182**		country x vocab < 200	ns
		vocab > 200	-1.95E-2*		country x vocab > 200	ns
Predicates	R^2 = .123	intercept	26.26**	R^2 = .078	country	-6.32*
		vocab size	ns		country x vocab	1.23E-2*
Closed Class	R^2 = .153	intercept	8.34**	R^2 = .021	country	ns
		vocab > 300	1.19E-2*		country x vocab	ns
Time Words	R^2 = .149	intercept	.927**	R^2 = .010	country	ns
		vocab size	1.76E-3*		country x vocab	ns
Sentence Complexity	R^2 = .718	intercept	2.72	R^2 = .001	country	ns
		vocab > 200	6.60E-2**		country x vocab > 200	ns

Vocabulary size predictors were added in step 1 and total variance was calculated. Country of origin and its interactions with vocabulary size were added in step 2 and additional variance was calculated. Finally, a backward regression was conducted to determine which predictors were reliable and calculate the β coefficients in the final model. Asterisks indicate p-values in the final model (* < .05, ** < .005).

Figure 1: The proportion of developmental milestones passes on the modified Ages and Stages Questionnaire for preschool adoptees and infant controls in Study 1. The younger preschool group was adopted between the ages of 2;5 and 3;9. The older preschool group was adopted between the ages of 3;10 and 5;6. Infant controls were matched based on vocabulary size.

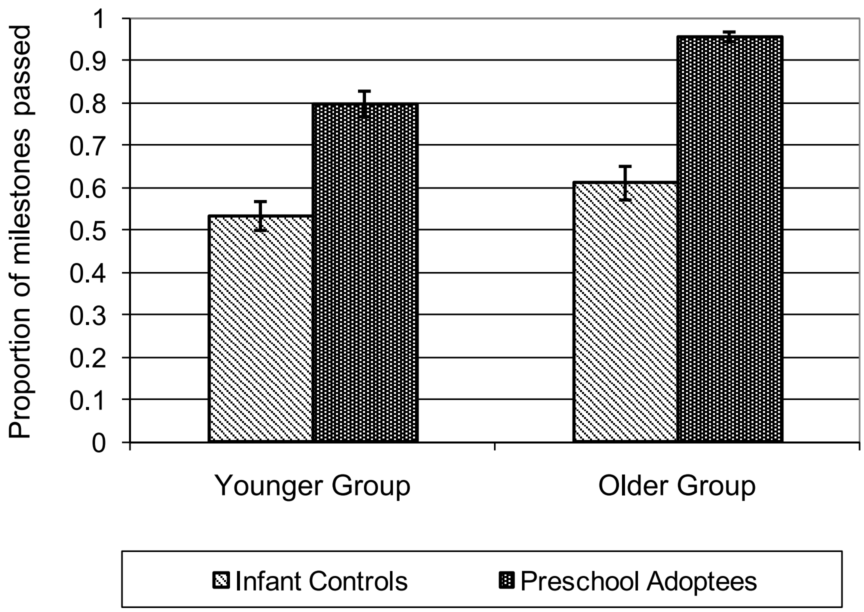


Figure 2: Vocabulary growth curves for the younger and older preschoolers in Study 1.

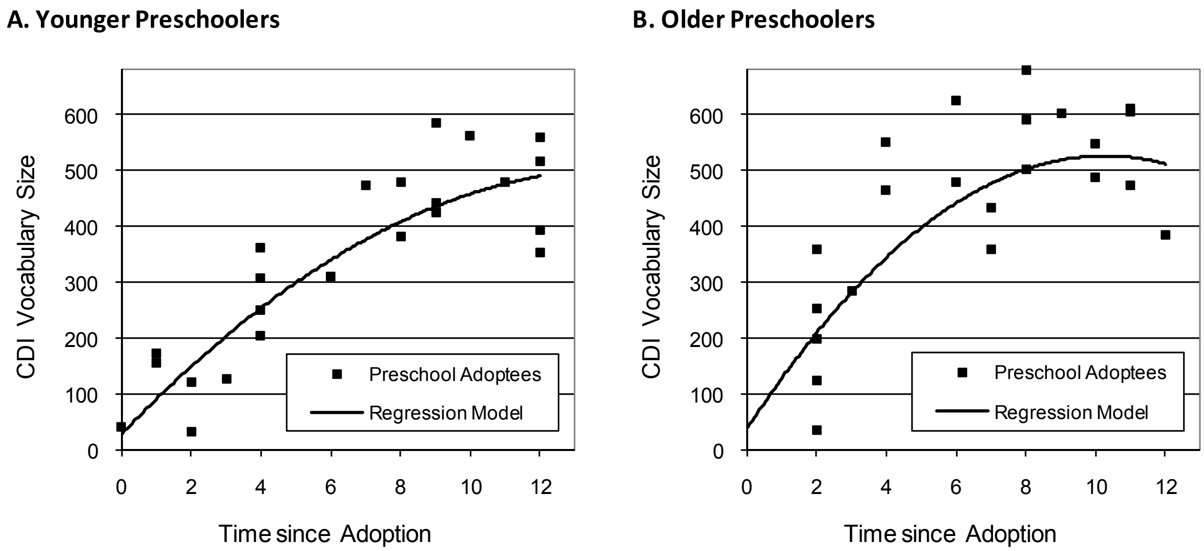


Figure 3: The proportion of social words in the child's vocabulary as a function of vocabulary size for younger and older preschoolers in Studies 1 and 2.

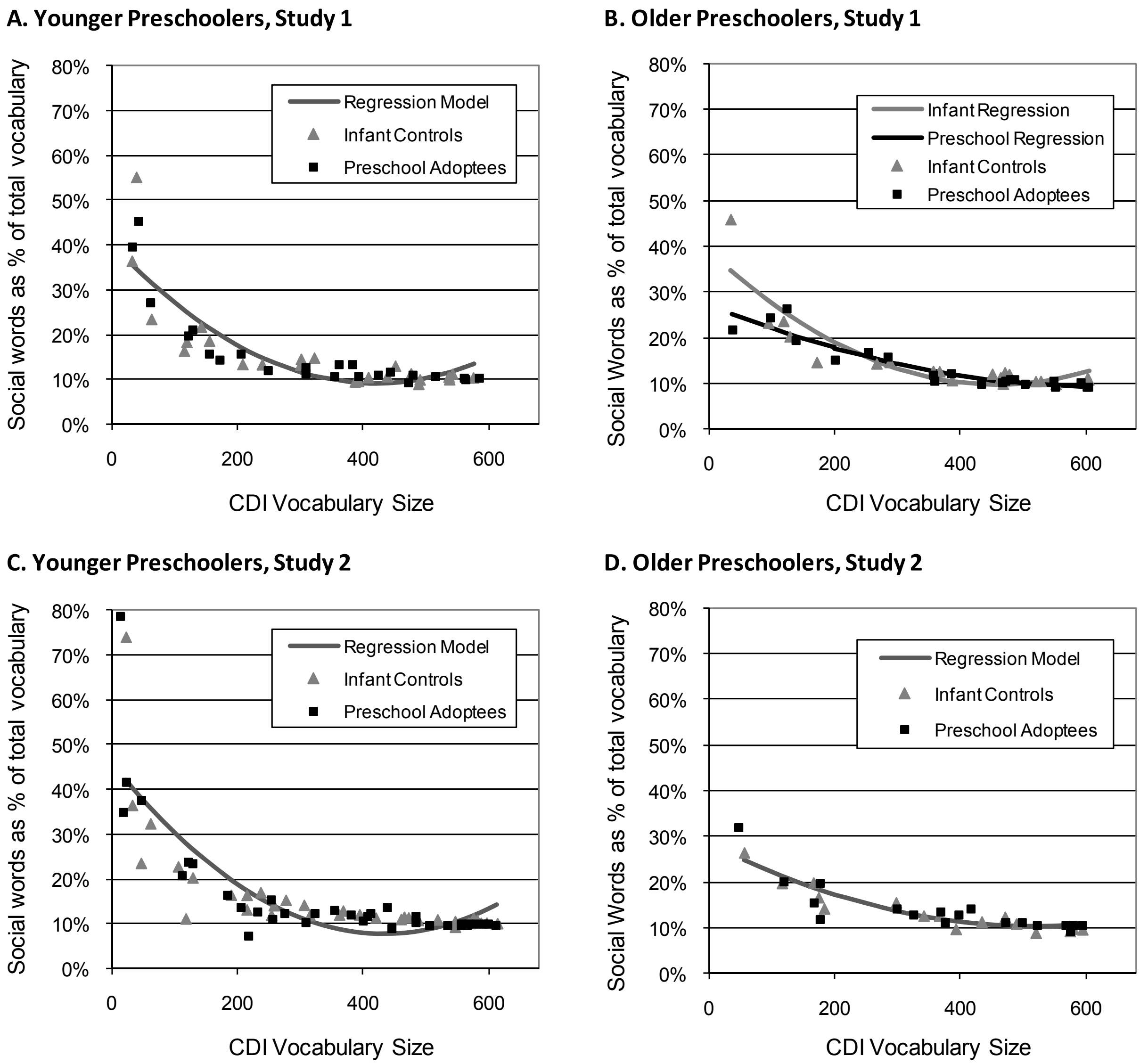


Figure 4: The proportion of nouns in the child's vocabulary as a function of vocabulary size for younger and older preschoolers in Studies 1 and 2.

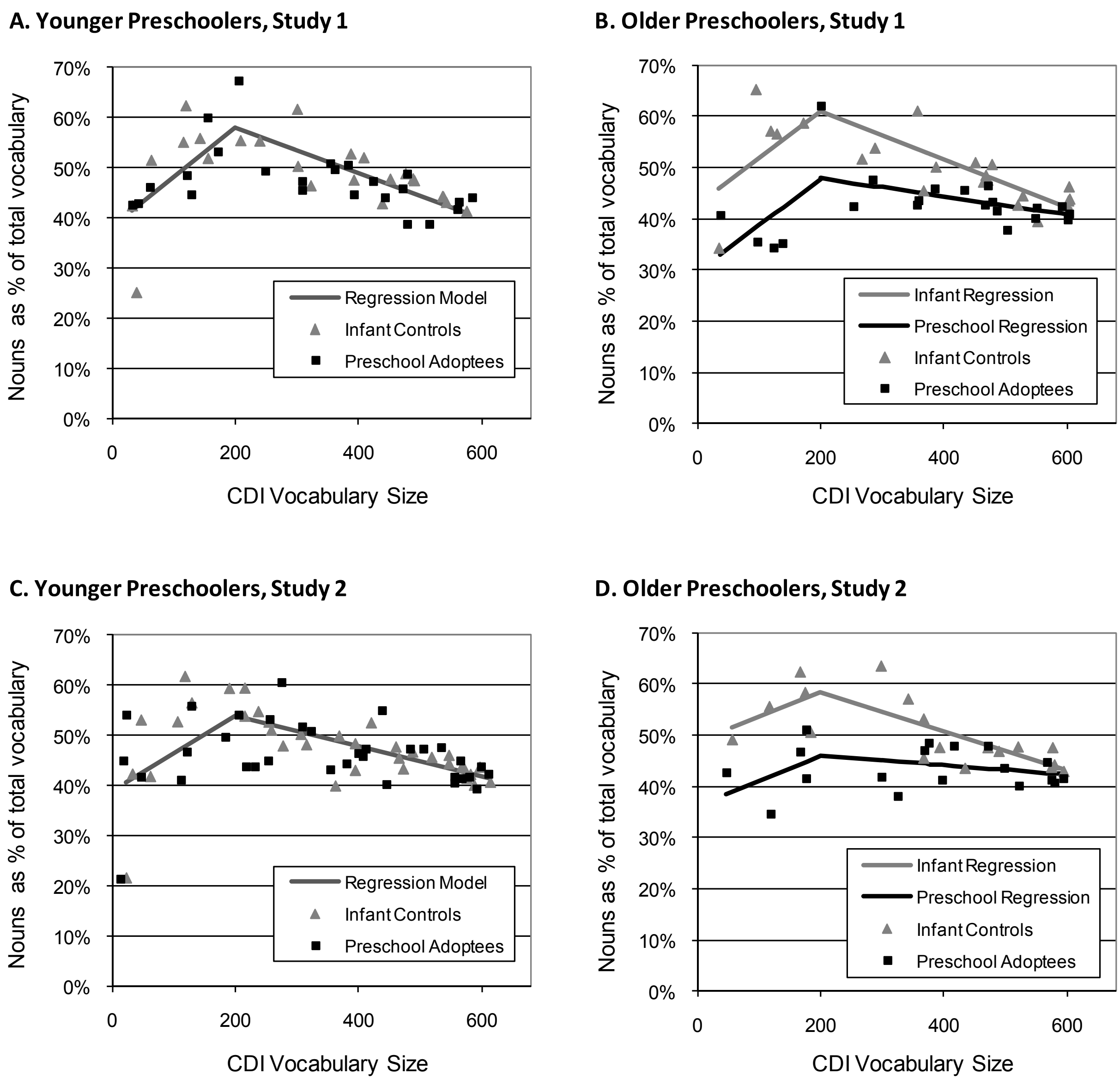


Figure 5: The proportion of predicates in the child's vocabulary as a function of vocabulary size for younger and older preschoolers in Studies 1 and 2.

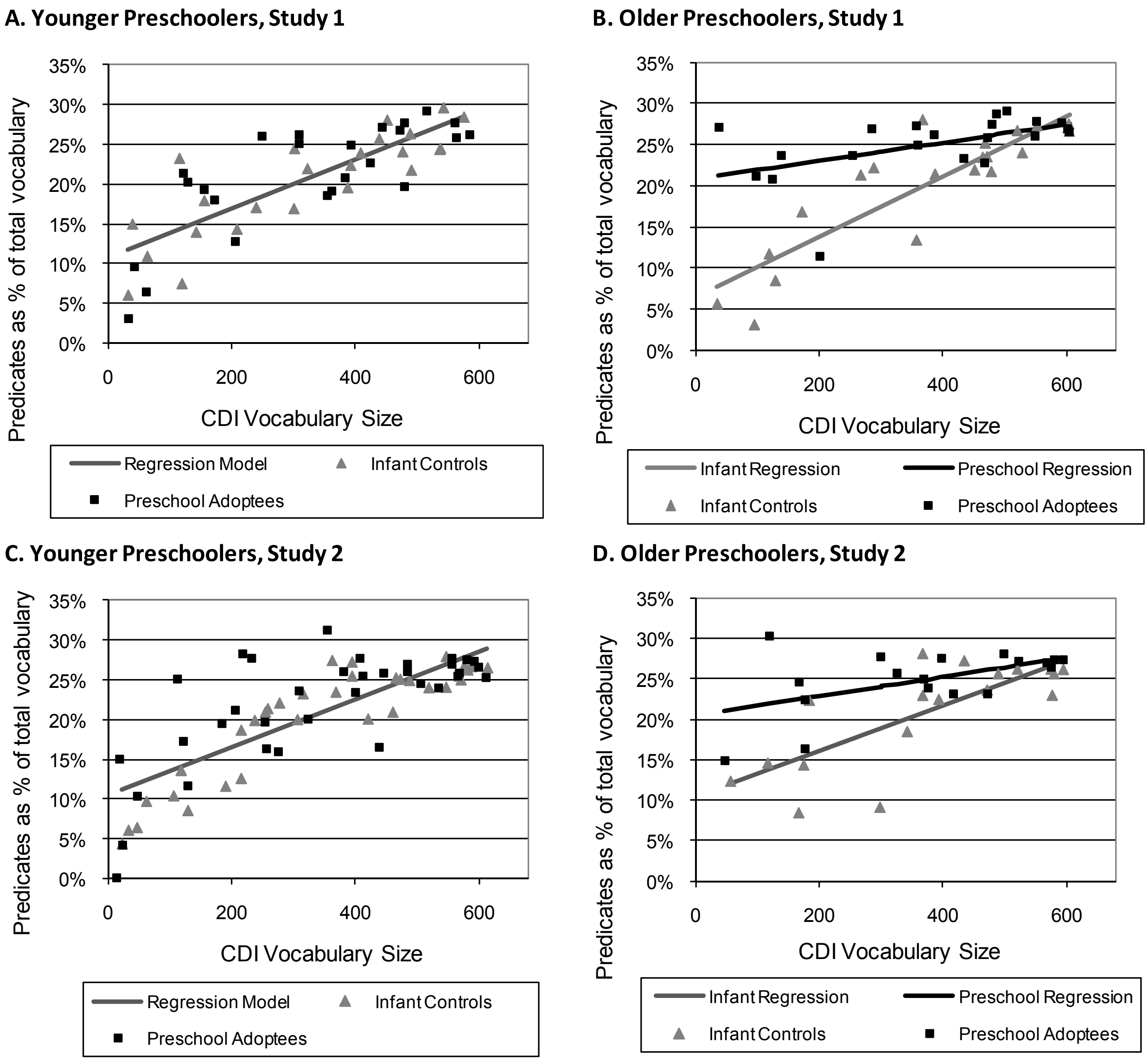


Figure 6: The proportion of closed-class words in the child's vocabulary as a function of vocabulary size for younger and older preschoolers in Studies 1 and 2.

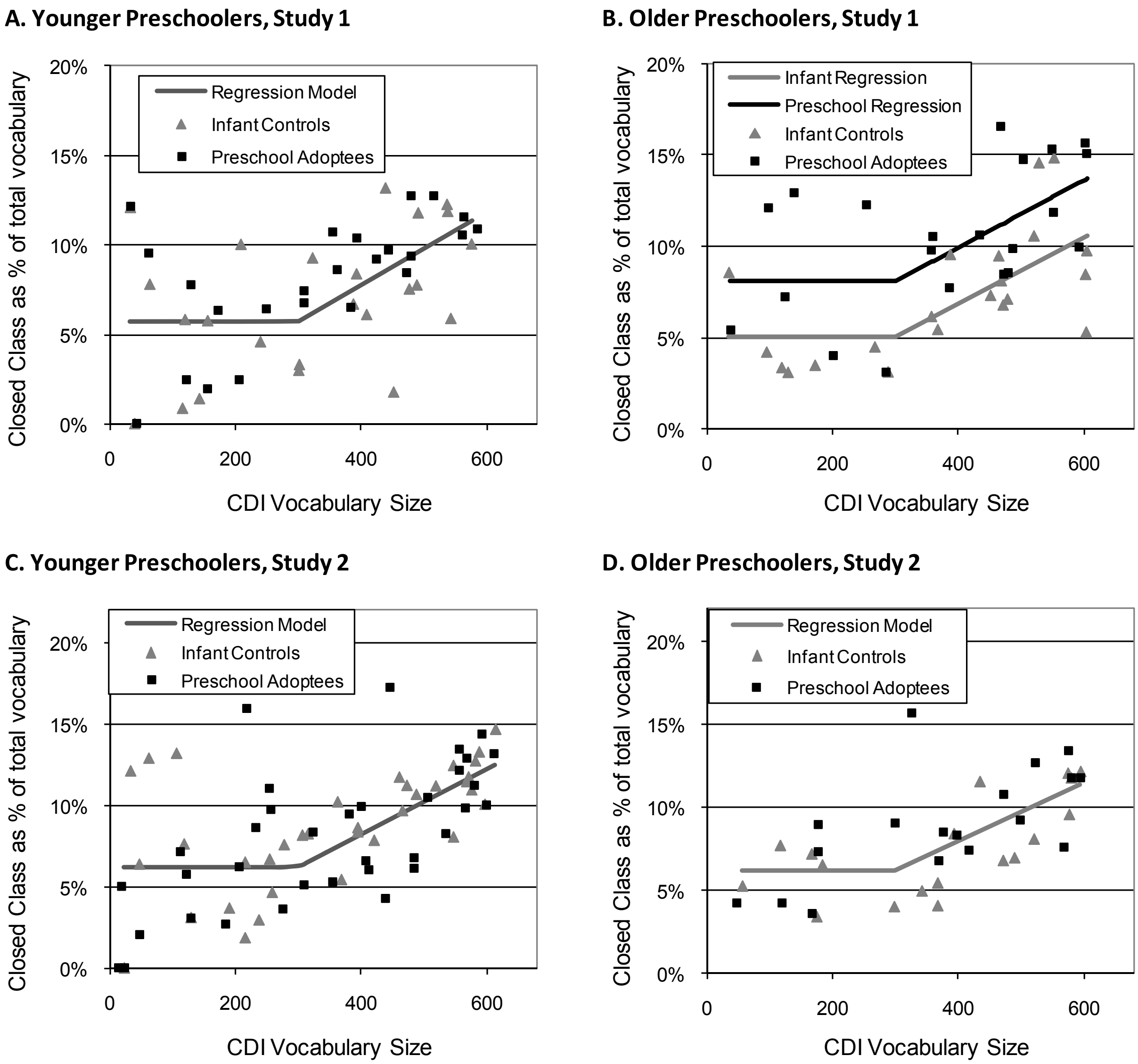


Figure 7: The proportion of words for time in the child's vocabulary as a function of vocabulary size for younger and older preschoolers in Studies 1 and 2.

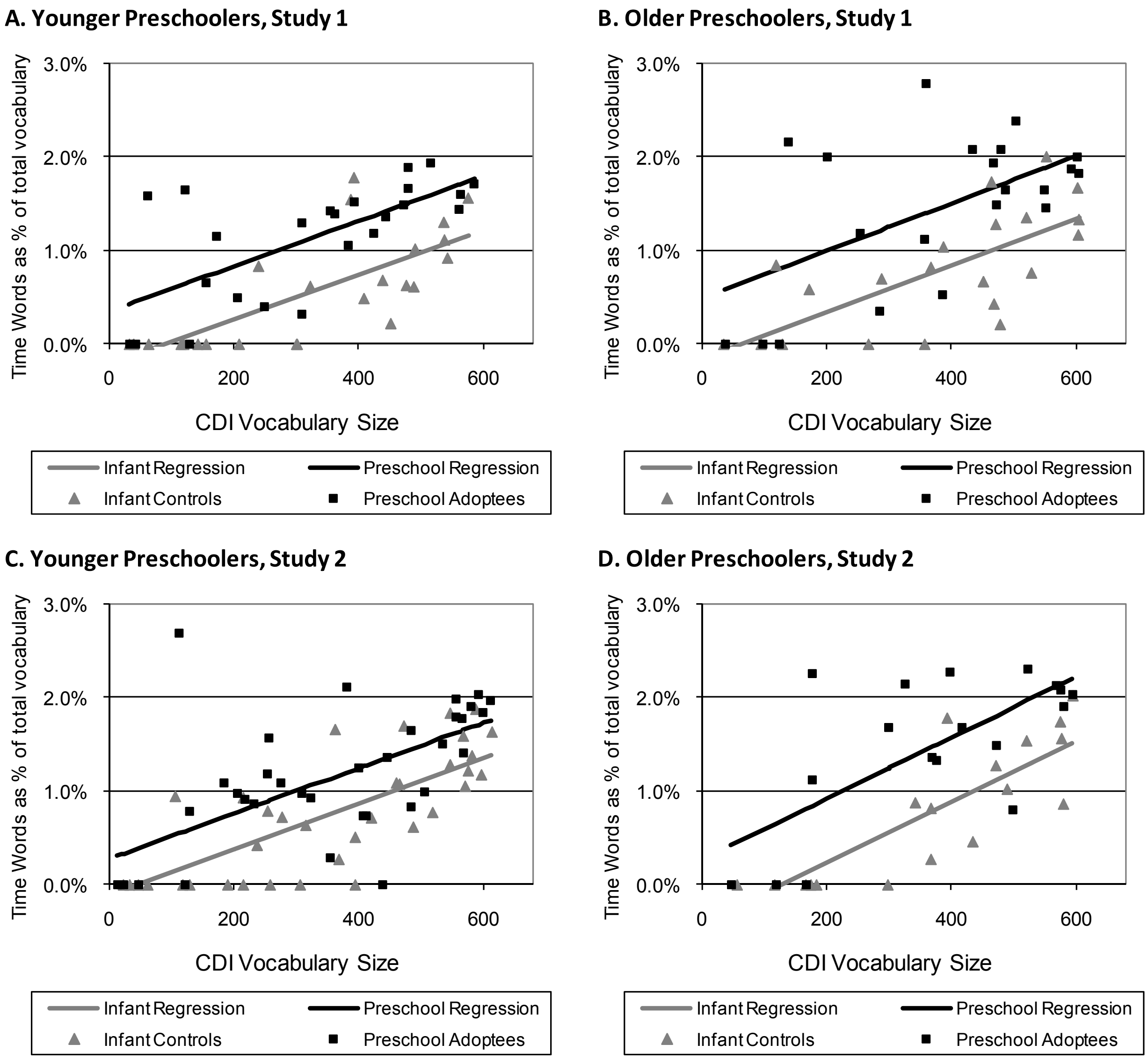


Figure 8: Children's performance on the sentence complexity scale as a function of vocabulary size in Study 1.

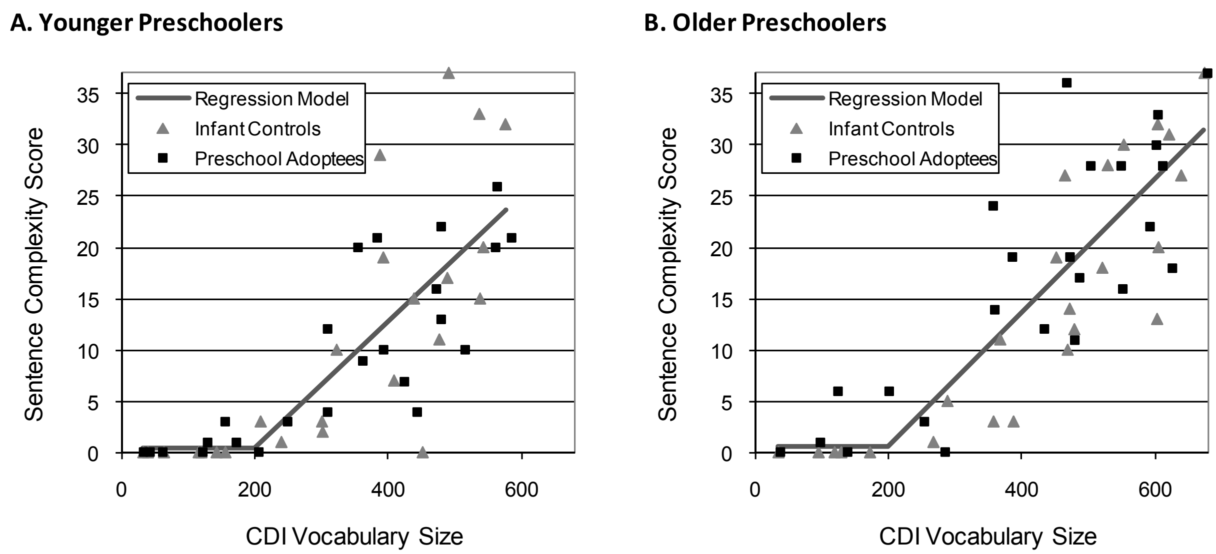


Figure 9: The mean length of child's longest reported utterances as a function of vocabulary size in Study 1.

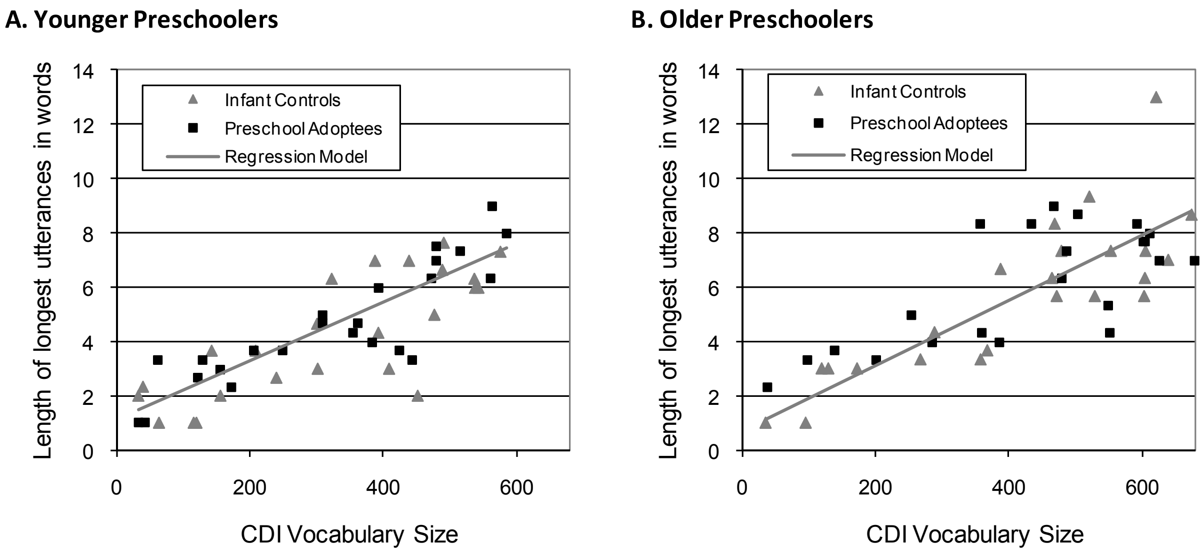


Figure 10: The proportion of nouns in the child's vocabulary as a function of vocabulary size and country of origin in Study 3.

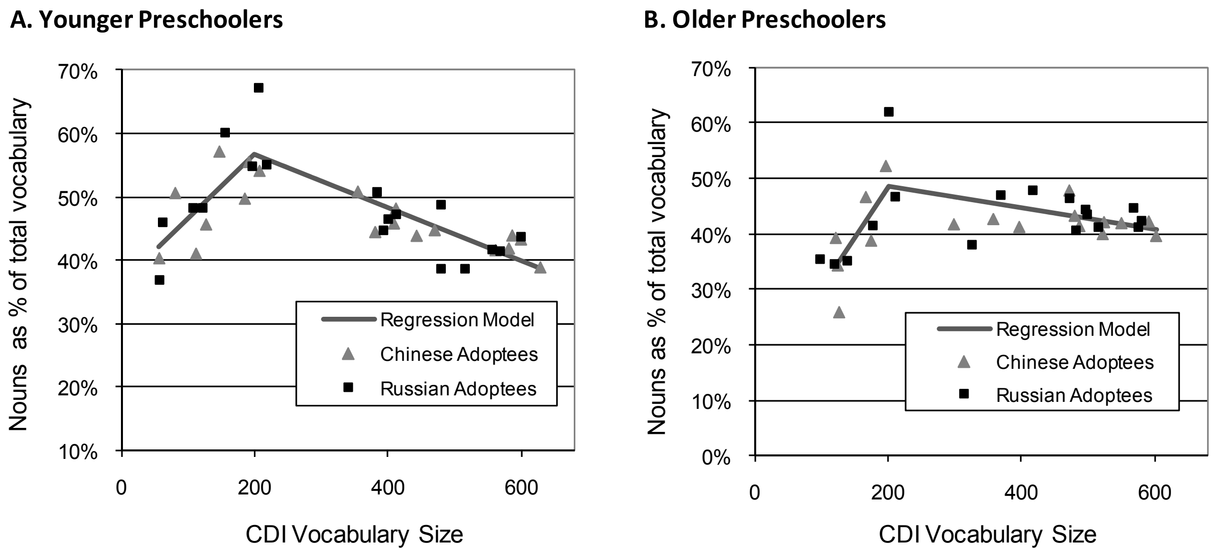
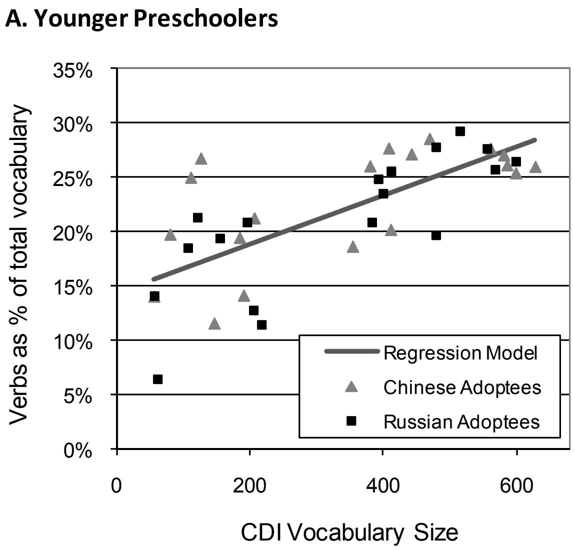


Figure 11: The proportion of predicates in the child's vocabulary as a function of vocabulary size and country of origin in Study 3.



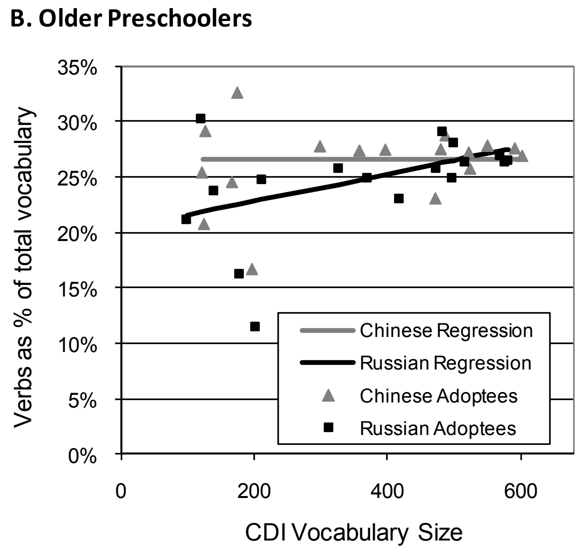
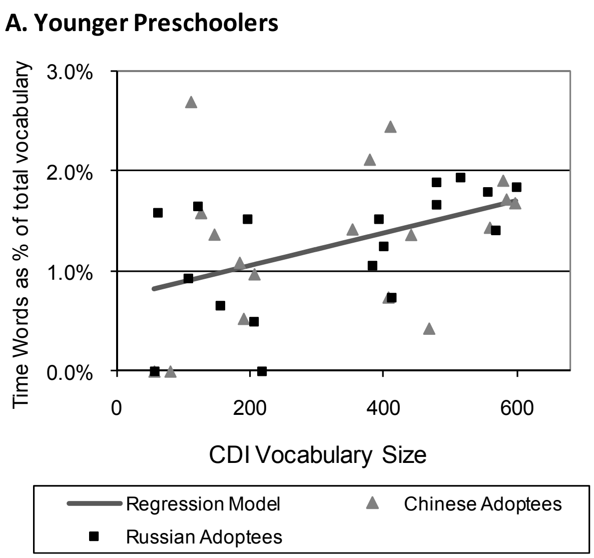
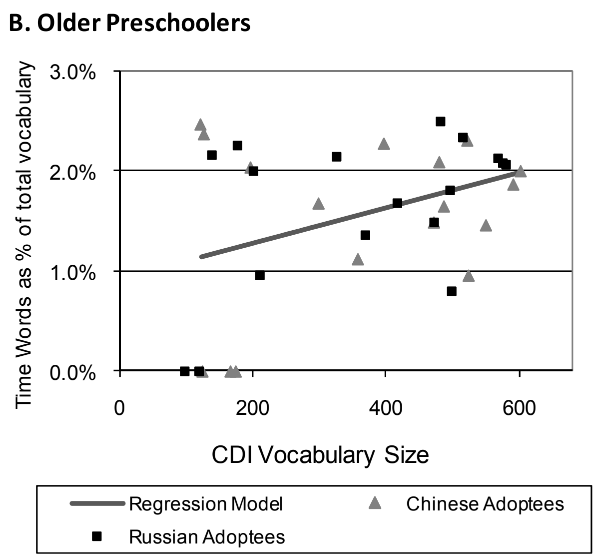


Figure 12: The proportion of words for time in the child's vocabulary as a function of vocabulary size and country of origin in Study 3.





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