Supplementary materials for:

Disentangling the effects of cognitive development and linguistic expertise: A longitudinal study of the acquisition of English in internationally-adopted children.

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This supplement contains additional data and analyses from the experiment reported in Snedeker, Geren & Shafto (under review). These analyses validate some of the central assumptions behind that research. The methods are fully described in that paper. Where it is necessary to retain coherence information from the original paper is repeated here. This supplement consists of four appendices.

Appendix A: Analyses of the children's linguistic input and their use of their birth language.

Appendix B: A comparison of the nonlinguistic abilities of adopted infants and adopted preschoolers

Appendix C: Analyses validating the CDI-2 as a measure of language development in internationally-adopted preschoolers.

Appendix D: The role of age and time in vocabulary growth of children adopted as infants and children adopted as preschoolers.

Abstract

Early language development is characterized by predictable changes in the words children produce and the complexity of their utterances. In infants these changes could reflect increasing linguistic expertise or cognitive maturation and development. To disentangle these factors, we compared the acquisition of English in internationally-adopted preschoolers and internationally-adopted infants. Parental reports and speech samples were collected for one year. Both groups showed the qualitative shifts that characterize first-language acquisition. Initially, they produced single-word utterances consisting mostly of nouns and social words. The appearance of verbs, adjectives and multiword utterances was predicted by vocabulary size in both groups. Preschoolers did learn some words at an earlier stage than infants, specifically words referring to the past or future and adjectives describing behavior and internal states. These findings suggest that cognitive development plays little role in the shift from referential terms to predicates but may constrain children's ability to learn some abstract words.

Appendix A: Analyses of the children's linguistic input and their use of their birth language.

A central premise of the present study is that internationally-adopted children typically stop speaking their birth language in the first few months after arrival and begin speaking English. The information that parents' provided in the background questionnaire supports this premise (see Table A1). The parents believed that at the time of adoption most of the preschoolers could produce 4-5 word sentences in their birth language (the highest level listed on the questionnaire). This information came from a variety of sources, often including people who had interacted with the child during the adoption process and were not directly affiliated with the orphanage. In contrast the parents of the infants typically believed that their child had not begun speaking at the time of adoption. Both groups of children were reported to have little or no continued exposure to their birth language. At the beginning of the study the parents of the preschoolers said that they used their birth language the majority of the time. However, by the end of the study, most parents reported that their children appeared to know fewer than 5 words in their birth language and rarely used it.

To verify the initial patterns of language use in the preschoolers and determine how quickly they changed, we analyzed the videotaped speech samples of the five oldest children (B, D, E, F & G). This included the two siblings (F & G) and another child (B) who had a younger sibling who was reported to speak with her in Russian at the beginning of the study. All speech samples from the child's first three months in the study were watched by a fluent speaker of the birth language who edited the English transcript to include all utterances produced by either the child or the parent that contained any words in the child's birth language. If, at the end of three months, ten percent or more of the child's utterances contained words in their birth language, the next two speech samples were analyzed (until the child met this criterion).

Table A1: Background Information about Participants

Participant	Sex	Age at arrival	Birth Language (country)	Developmental concerns*	Knowledge of birth language (first / final session)	Continued exposure to birth language (first / final session)	Frequency of use of birth language (first / final session)
Preschool Adoptees							
A	M	2;5	Russian	1, 2	≤ 5 words / none	never / never	50% / < 25%
B	F	5;0	Russian	none	4-5 word sentences / 5-15 words	daily sibling** / never	> 75% / never
C	F	3;1	Russian (Belarus)	none	4-5 word sentences / ≤ 5 words	sitter 1 day a week /2 days a month (sitter)	> 75% / never
D	F	5;6	Russian	1	4-5 word sentences / none	never / rarely	> 75% / never
E	M	4;3	Mandarin	3	4-5 word sentences / no data	never / no data	> 75% / no data
F	M	5;4	Russian	2	4-5 word sentences / none	never / rarely	> 75% / never
G	M	4;2	Russian	2	4-5 word sentences / none	never / rarely	> 75% / never
H	F	2;9	Longyou (China)	3	4-5 word sentences / ≤ 5 words	never / never	> 75% / never
I	F	3;1	Russian	3	some 2-word phrases / ≤ 5 words	never / rarely	< 25% / never
Infant Adoptees							
1	F	1;4	Mandarin	none	none / 5-15 words	never / 1 class each week	never / < 25%
2	F	1;2	Cantonese	1	never learned	never / never	never / never
3	F	1;3	Mandarin	1	never learned	never / never	never / never
4	M	0;6	Russian	1	never learned	never / rarely	never / never
5	F	0;10	Cantonese	none	never learned	never / never	never / never
6	F	0;11	Cantonese	none	never learned	never / rarely	never / never
7	F	1;4	Mandarin	none	never learned	never / rarely	never / never
8	F	0;7	Russian (Kazakhstan)	none	never learned	never / rarely	never / never
9	F	1;0	Mandarin	1	none / some 2-word phrases	1 class a week / 1 class a week	never / < 25%
10	F	1;3	Russian	none	never learned	never / never	never / never
11	F	1;0	Mandarin	none	≤ 5 words / ≤ 5 words	never / rarely	never / never
12	F	1;1	Cantonese	none	never learned	never / never	never / never
13	F	0;11	Cantonese	no data	none / no data	never / no data	never / no data
14	F	1;3	Cantonese	none	≤ 5 words / none	never / rarely	never / never

* 1 = developmental delays, 2 = hearing related (all participants had normal hearing in at least one ear), 3 = physical health.

** Younger adoptive sibling, adopted at same time.

Figure A1: Language use in videotaped speech samples for the five oldest adopted preschoolers.

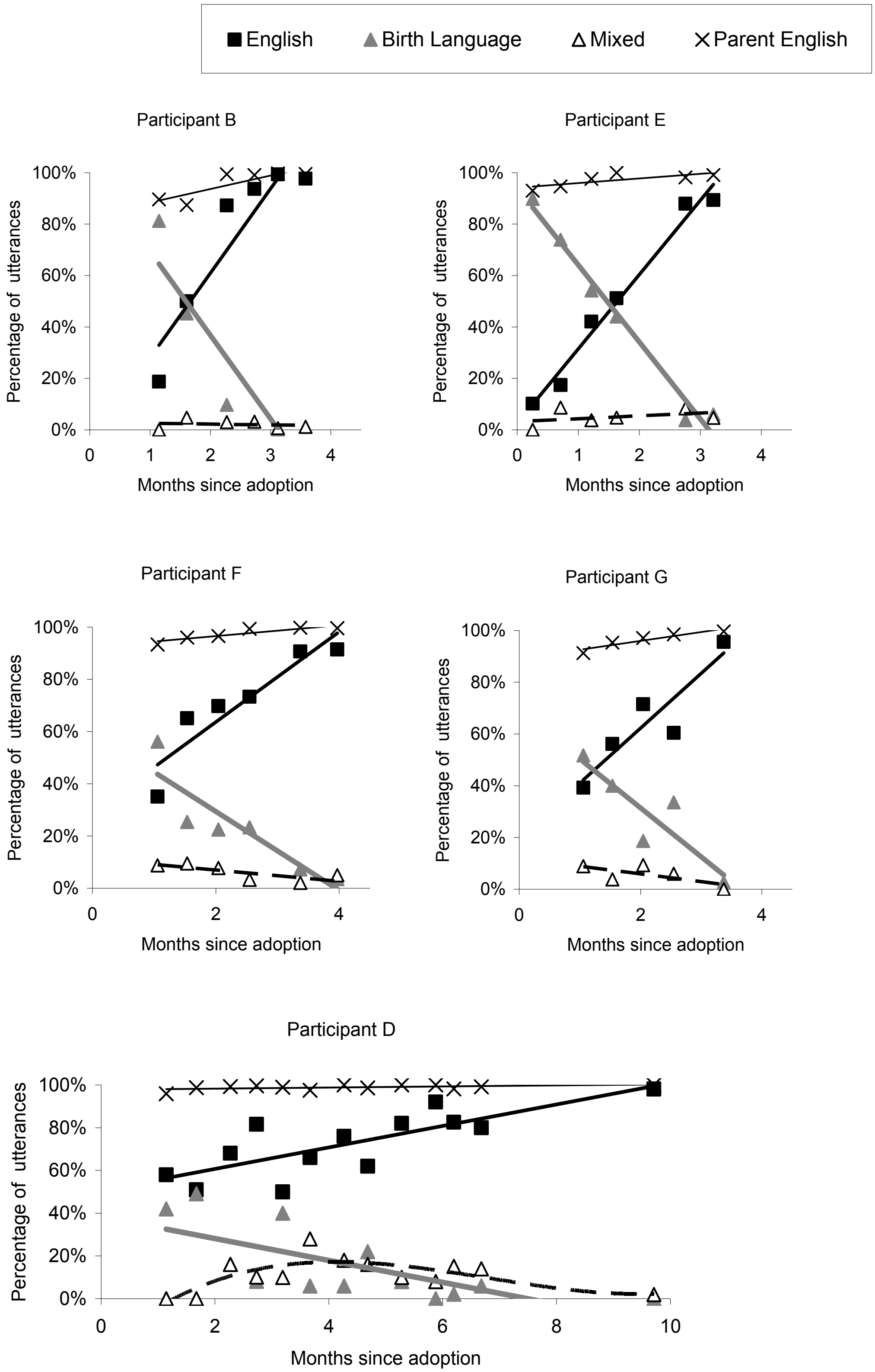

Figure A1 depicts the proportion of each child's utterances that were in their birth language, in English or mixed. The proportion of the parent's utterances that were entirely in English is also shown. The pattern is similar across all five children. The proportion of utterances in the birth language dropped quickly. By 2 months all of the children were using English more often than their birth language. The parents spoke predominantly in English from the first session (most had minimal knowledge of the child's language). For four of the five children, there were very few mixed utterances and the birth language was seldom spoken after 3.5 months. Child D continued to use her birth language for the first six months of the study and produced more mixed utterances. Her parents each took one year of college level Russian, however, her mother reported that they spoke to her almost entirely in English and the speech samples confirmed this. Her first follow-up session occurred at 10 months and at this time she was producing very little Russian. By the end of the study her mother reported that she seemed to remember only about 5-15 words. Thus it appears that she also lost her birth language, just at a somewhat slower pace.

Appendix B: A comparison of the nonlinguistic abilities of adopted infants and adopted preschoolers

The goal of the present study is to look at the effects of cognitive development and maturation on language acquisition. By studying internationally-adopted children, we can get a stronger manipulation of cognitive status, relative to linguistic experience, than we could through correlational studies of typical first-language acquisition. We also arguably have a more stable manipulation of cognitive status across different domains of functioning than could be achieved by comparing typically-developing children to those with developmental disorders. However, there is one unique feature of this population which potentially complicates our findings: most internationally-adopted children spend their early years in orphanages, and orphanage care is associated with developmental delays (Albers, Johnson, Hostetter, Iverson & Miller, 1997; Miller & Hendrie, 2000).

We recognize the severity and importance of these delays, but we believe that they do not jeopardize the validity of this approach. The logic of this study does not require that the adopted preschoolers be cognitively equivalent to their American-born age mates; it only requires that they be at least as advanced as the infant learners who have passed the linguistic milestones that we are studying. There are good reasons to believe that they are. The most alarming reports about cognitive delays in internationally-adopted children come from studies relying on clinical assessments conducted in English shortly after the child has arrived in the United States (see e.g., Albers et al., 1997; Miller & Hendrie, 2000). Research on children living in Russian orphanages suggests that, while delays are common in this population, they are generally moderate in magnitude (Sloutsky, 1997; The St. Petersburg-USA Orphanage Research Team, 2005). In addition, the selection process for adoption favors children who have the strongest cognitive skills and the best physical health (The St. Petersburg-USA Orphanage Research Team, 2005). Studies that have followed internationally-adopted children over time confirm that most of them do not have global and lasting cognitive impairments (Pomerleau, Malcuit, Chicoine, Seguin, Belhumeur, Germain, Amyot et al., 2005; Cohen, Lojkasek, Zadeh, Pugliese & Kiefer, 2008). For example, Cohen and colleagues found that when adoptees from China were tested shortly after arrival their standard scores on the Bayley Mental Development Index (Bayley, 1993) suggested that they had substantial developmental delays (M = 77). However, just six months later most of the children fell within the normal range (M = 93). Such findings suggest either that the developmental deficits of adopted children clear up rapidly after arrival or that tests administered shortly after adoption underestimate children's abilities.

To assess the cognitive abilities of the children in our sample, the parents of both the infants and the preschoolers were asked to fill out a modified version of the Ages and Stages Questionnaires (ASQ). The ASQ is 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 in our judgment required a linguistic prompt or response. The remaining questions were assigned to one of three age categories, based on the age by which children are expected to acquire the ability as listed in the ASQ manual. The early milestones were ones that we would expect typically developing children to pass prior to developing the linguistic skills assessed on the CDI-2 (11-21 months). The concurrent milestones were ones that typically emerge simultaneously with these linguistic abilities (21- 36 months), while the late milestones would typically be achieved after these linguistic abilities developed (36 – 60 months).

Parents were asked to fill out the modified ASQ every three months but only after the child had been with their adoptive family for at least three months. Answering the questions on the ASQ, requires fairly extensive knowledge of a child's abilities in a wide range of contexts, and presumably this knowledge takes time to acquire. Thus the infants typically received the ASQ at sessions 1, 4, 7 and 10, while the preschoolers typically received it at sessions 3, 6 and 9 with some variation depending on when they enrolled.

Figure B1 graphs the total ASQ score relative to age across all sessions for the total sample (including the children who did not complete the study). There was a strong correlation between age and total ASQ score for both infants (r =.82) and preschoolers (r =.62), indicating that the modified ASQ is clearly sensitive to development in this age range.

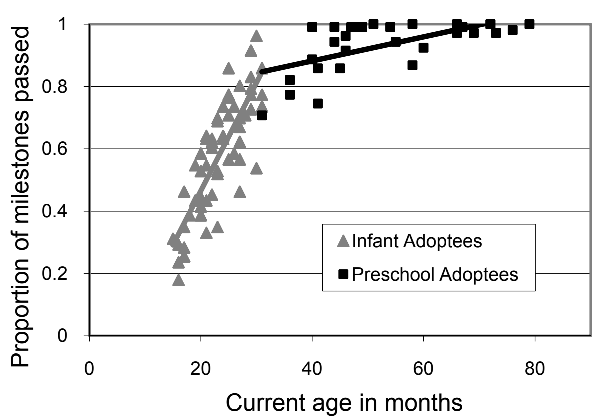

Figure B1: The modified Ages and Stages Questionnaire is sensitive to developmental change from 16 to 30 months

Both the infants and the preschoolers received one ASQ at around 3 months after language onset and another at approximately 10 months after onset. To compare the groups we analyzed the ASQ's that were given at these two times (+/- 1 month) and calculated the mean proportion of early, concurrent and late milestones that were passed. Each of the two sets of scores was submitted to an ANOVA with one within participant variable (level of milestone) and one between participant variable (infant or preschool adoptee). As Figure B2 illustrates there was a robust effect of participant group. The preschoolers passed far more milestones than the infants both at 3 months [$F(1,21)=42.25$, $p < .001$] and at 10 months [$F(1,19)=36.02$, $p < .001$] . Unsurprisingly, there was also a significant effect of milestone type with early milestones being mastered before concurrent ones, and concurrent milestones before the late ones [$F(2,42)=120.74$, $p < .001$; $F(2,38)=95.91$, $p < .001$]. Finally, there was a reliable interaction indicating that preschoolers did particularly well on the more difficult milestones [$F(2,42)=20.48$, $p < .001$; $F(2,38)=29.78$, $p < .001$].

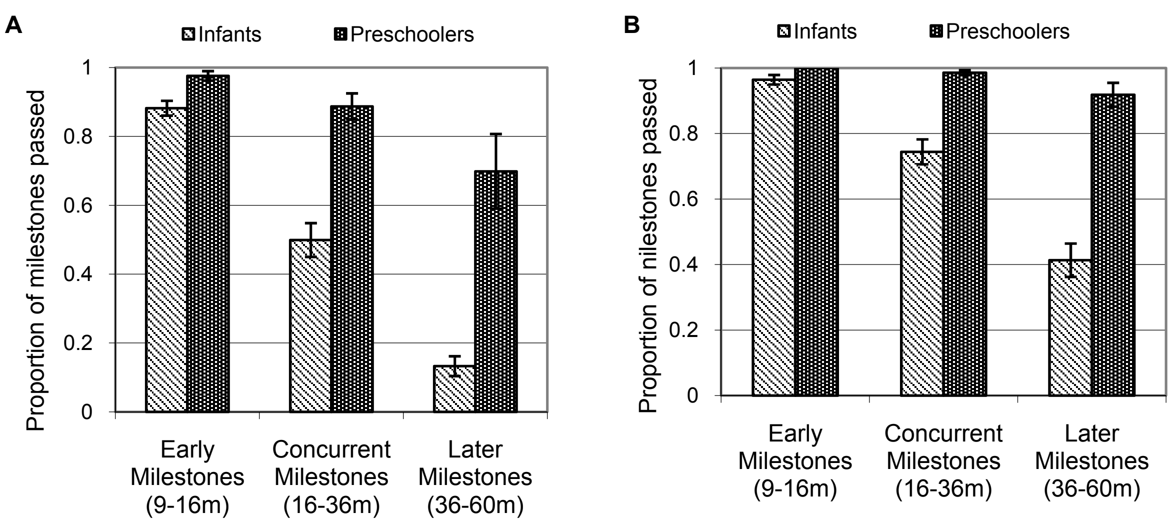

Figure B2: Modified ASQ scores A) early in language acquisition (approximately 3 months after language onset) B) later in acquisition (approximately 10 months after onset).

Ideally, our manipulation of developmental status would be sufficiently strong that our older group would be more mature at the beginning of the study than our younger group is at the end. To check this we ran a third ANOVA comparing the preschoolers at three months with the infants at ten. There was a large and robust effect of age group, along with a main effect of level of milestone and an interaction [$F(1,21)=7.37$, $p < .05$; $F(2,42)=66.55$, $p < .001$; $F(2,42)=5.92$, $p < .005$]. Towards the beginning of the study the older children had passed more of the concurrent and late developmental milestones than the infants had toward the end of the study. These results confirm what is readily apparent when watching the children's videotapes: whatever delays they had, these preschoolers were clearly more cognitively sophisticated and motorically skilled than the bumbling toddlers who typically take on this linguistic challenge.

Appendix C: Analyses validating the CDI-2 as a measure of language development in internationally-adopted preschoolers.

Our primary measure of lexical development and the onset of combinatorial speech was the MacArthur-Bates Communicative Development Inventory 2 (CDI-2). The CDI-2 (Fenson et al., 1993) is a parent report measure which has been is normed and validated for children 16 to 30 months of age. This measure has also been used to track language development in older children with limited language skills (Thal, O'Hanlon, Clemmons & Frailin, 1999; Singer-Harris et al., 1997). To validate the parental report, speech samples were collected by the participating parent who was instructed to videotape herself interacting with her child two times a month for 30-40 minutes. Families were given a standard set of toys to use while making the recordings. Tapes were transcribed in the CHILDES format (MacWhinney, 2000).

For the present analyses, we analyzed speech samples for eight of the preschoolers and eight of the infants.[1] For each child we selected up to three CDI-2's: one in which the parent reported that they were not yet combining words, one in which they were reported to sometimes combine words, and one in which they were reported to often combine words. When more than one CDI-2 was available, sessions were selected so as to match the vocabulary level of the infants and preschoolers. Some of the children did not have a tape for one of these three time points, thus there were 41 sessions in the analysis rather than 48 (2 missing data points for the infants, 5 for the preschoolers).

We analyzed the first 100 child utterances excluding exact repetitions and self-repetitions, utterances in which the child repeated a word at the request of the parent, and utterances that were entirely incomprehensible or entirely in the child's native language. The CLAN program

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[1] The speech samples for Preschooler C were too short to support these analyses. The eight infants were selected based on the date when they completed the study. Infants 8, 9 and 11-14 were excluded from this analysis.

(MacWhinney, 2000) was used to calculate the child's mean length of utterance in morphemes (MLU), as well as the total number of different word types produced. If the child produced fewer than 100 utterances during the session (which happened often in the earliest tapes), then we analyzed all the utterances from that session that met our inclusion criteria. To validate the CDI-2 we conducted two analyses: one exploring the relation between CDI-2 vocabulary size and number of word types produced and a second exploring the relation between the parental report of combinatorial speech and the child's MLU.

In the first analysis, the number of word types was treated as the outcome variable and CDI-2 vocabulary was entered as a level-one predictor (Table C1). The number of word types was highly correlated with CDI-2 vocabulary size ($R^2_{y,y}$= .53), mirroring the pattern observed in previous studies of typically developing infants (Beeghely, Jernberg & Burrows, 1989). To explore whether the relationship between parental reports and spontaneous production differed between the infant and preschool adoptees, we tested additional models in which participant group was included as a level-two predictor of the intercept or slope. In neither model was the effect of participant group reliable, suggesting that the relation between reported and observed vocabulary was similar for infants and preschoolers.

In the second analysis MLU was treated as the outcome variable and parental report of combinatorial speech was treated as a categorical predictor (Table C2). Two dummy variables were created: one marking the session in which the child was reported to produce combinations "sometimes" and the other marking the session where they were reported to do so "often". These two predictors accounted for 35% of the variance in MLU. Most of the variance was attributable to "often" producing combinations (partial $R^2_{y,y}$=.32). There was no difference in MLU for the sessions in which the children were reported to sometimes combine words and those in which they were reported to never combine them. This is consistent with previous studies, which find that judgments of “often" combining are both more stable and more predictive (see Fenson et al., 1994). The model with the best fit included participant group as a predictor but only for children who were “sometimes” combining. Infants who had just begun combining only demonstrated this skill sporadically (mean MLU = 1.35), while the preschoolers did so more frequently (mean MLU = 1.57). Once this difference was accounted for there was no effect of participant group on overall utterance length or on the dummy variable for “often” combining words, suggesting that parents of older and younger children were using the scale in a similar way. In sum, the parental report appears to be a valid and parallel measure of early production in these two populations.

Table C1: Hierarchical Models of the Relation between Word Types in Speech Sample and Parental Report of Vocabulary Size

		Parameter	Unconditional Model	**Growth Model**	Growth Model 2	Growth Model 3
Fixed Effects						
Initial Number of Types	Intercept	γ_{00}	42.86** (3.66)	**23.63** (4.25)**	19.67** (4.67)	23.52** (4.16)
π_{0i}	Group: preschooler relative to infant	γ_{01}			9.55 (5.47)	
Effect of Vocabulary Growth	Intercept	γ_{10}		**.089** (.014)**	.086** (.013)	.075** (.017)
π_{2i}	Group: preschooler relative to infant	γ_{11}				.026 (.018)
Variance Components						
Level 1	Within person	σ^2_ε	533.64**	**196.79***	205.38*	218.04*
Level 2	Initial Types	σ^2_0	.493	**62.14***	30.19	38.25*
	Effect of Vocabulary	σ^2_1		**.00059**	.00022	.00033
Pseudo R2 statistic and Goodness-of-fit						
	$R^2_{y,\hat{y}}$			**0.531**	0.570	0.532
	Deviance		372.01	**340.58**	337.30	338.30
	AIC		378.01	**352.58**	351.30	352.30
	BIC		380.33	**357.22**	356.71	357.71
	# parameters		3	**6**	7	7

* p < .05, ** p < .005. Outlined cells indicate the model selected on the basis of fit; the parameter estimates and standard errors for the predictors in that model; and the total variance accounted for by that model. The grey cells indicate the effects of participant group.

Table C2: Hierarchical Models of the Relation between MLU in Speech Sample and Parental Report of Word Combinations

		Parameter	Unconditional Model	Growth Model	Growth Model 2	**Growth Model 3**	Growth Model 4
Fixed Effects							
Initial MLU	Intercept	γ_{00}	1.47** (.077)	1.19** (.096)	1.10** (.113)	**1.18** (.097)**	1.22** (.105)
π_{0i}	Group: preschooler relative to infant	γ_{01}			.208 (.135)		
Sometimes combining (0=never or often, 1=sometimes)	Intercept	γ_{10}		.173 (.125)	.158 (.124)	**-.005 (.139)**	.144 (.084)
π_{2i}	Group: preschooler relative to infant	γ_{11}				**.423* (.186)**	
Often combining (0=never or sometimes, 1=often)	Intercept	γ_{20}		.602** (.113)	0.581** (0.118)	**0.616** (0.112)**	0.605** (0.170)
π_{2i}	Group: preschooler relative to infant	γ_{21}					-.061 (.211)
Variance Components							
Level 1	Within person	σ^2_ε	.173**	.0720*	.0785*	**.0687***	.0345*
Level 2	Initial MLU	σ^2_0	.0242*	.0274	.0189	**.0312**	.0987**
	Sometimes	σ^2_1		.0326	.0158	**.00579**	
	Often	σ^2_2					.129**
Pseudo R2 statistic and Goodness-of-fit							
	$R^2_{\mathrm{v,v}}$			0.354	0.425	**0.454**	0.344
	Deviance		47.51	24.24	22.54	**19.78**	24.18
	AIC		53.51	38.24	38.54	**35.78**	40.18
	BIC		55.83	43.65	44.72	**41.96**	46.36
	# parameters		3	7	8	**8**	8

* $p < .05$, ** $p < .005$. Outlined cells indicate the model selected on the basis of fit; the parameter estimates and standard errors for the predictors in that model; and the total variance accounted for by that model. The grey cells indicate the effects of participant group.

Appendix D: The role of age and time in vocabulary growth of children adopted as infants and children adopted as preschoolers.

The adopted preschoolers and infants differed on three temporal dimensions. The infants had been in the U.S. longer, they were younger at the time of adoption and they were still younger at the time of data collection. In our two level hierarchical models, we can model the age of the child and the time since adoption as level-one predictors. Since these two variables are perfectly correlated within an individual child (as more time passes both grow at the same rate) they are equivalent and redundant as level-one predictors. However, which description of time we choose can affect how consistently time is modeled across children, changing the variance at level two and affecting the fit of the model to the data. In contrast the age of the child at the time of adoption would be modeled as a level-two predictor. It varies across children but is constant within a child.

To understand how each of these temporal variables influences word learning, we began by looking at the two age groups separately. For both age groups we compared the unconditional model to two other models: one with age as a level-one predictor and one with time since adoption as a level-one predictor. After we determined which of these representations of time was most informative we explored the effect of age of adoption on the vocabulary growth rate. To minimize the effects of ceiling-level performance on growth rates, we identified the first session in which the participant knew at least 90% of the words on the CDI-2 (612) and then removed all subsequent data points for that participant from the analysis. Six sessions were removed from four preschoolers and three sessions were removed from one infant.

Table D1: Hierarchical Models of Vocabulary Growth in Infant Adoptees

		Parameter	Unconditional Model	Time Growth Model	**Age Growth Model**	Time and Age Model	Age Growth Model 2	Age Growth Model 3
Fixed Effects								
Initial vocabulary size	Intercept	γ_{00}	212.78** (24.52)	305.60** (51.60)	**-799.55** (83.71)**	-794.41** (116.69)	-727.69** (136.73)	-800.69** (84.11)
π_{0i}	Age of Arrival	γ_{01}					-5.97 (8.81)	
Rate of Change (by time since arrival)	Intercept	γ_{10}		41.16** (4.35)		1.32 (9.82)		
Rate of Change (by current age)	Intercept	γ_{20}			**41.05** (4.31)**	39.84** (8.90)	41.09** (4.32)	45.78** (6.98)
π_{2i}	Age of Arrival	γ_{21}						-0.383 (.447)
Variance Components								
Level 1	Within person	σ^2_ε	29792.30**	2176.83**	**2171.33****	2173.82**	2168.78**	2169.04**
Level 2	Initial vocabulary	σ^2_0	5122.90**	31697.88**	**81165.32****	13946.68**	83846.65**	82028.09**
	Rate of change by time	σ^2_1		250.84**		226.60**		
	Rate of change by age	σ^2_2			**225.61****		227.09**	221.17**
Pseudo R2 statistic and Goodness-of-fit								
	$R^2_{y,y}$			0.389	**0.440**	0.444	0.456	0.463
	Deviance		2076.14	1755.52	**1742.11**	1741.42	1741.63	1741.31
	AIC		2082.14	1767.52	**1754.11**	1755.42	1755.63	1755.31
	BIC		2084.06	1771.35	**1757.94**	1759.89	1760.10	1759.78
	# parameters		3	6	**6**	7	7	7

* $p < .05$, ** $p < .005$. Outlined cells indicate the model selected on the basis of fit; the parameter estimates and standard errors for the predictors in that model; and the total variance accounted for by that model. The dark grey cells indicate the effects of time since adoption (an alternate measure of time), while the light grey cells indicate the effects of age at adoption.

Table D2: Hierarchical Models of Vocabulary Growth in Preschool Adoptees

		Parameter	Unconditional Model	**Time Growth Model**	Age Growth Model	Time and Age Model	Time Growth Model 2	Time Growth Model 3
Fixed Effects								
Initial vocabulary size	Intercept	γ_{00}	308.62** (28.13)	**0.074 (25.33)**	-3283.75** (660.45)	-88.34 (95.78)	-88.32 (95.72)	-1.05 (24.10)
π_{0i}	Age of Arrival	γ_{01}					1.84 (1.92)	
Rate of Change (by time since arrival)	Intercept	γ_{10}		**66.18** (8.51)**		64.19** (8.77)	66.03** (8.51)	21.68 (24.28)
π_{2i}	Age of Arrival	γ_{11}						0.932 (0.639)
Rate of Change (by current age)	Intercept	γ_{20}			65.18** (8.77)	1.84 (1.92)		
Variance Components								
Level 1	Within person	σ^2_ε	45288.79**	**2898.94****	2849.81**	2914.83**	2914.83**	2869.30**
Level 2	Initial vocabulary	σ^2_0	94.39	**3448.65****	3223694.19**	3059.95**	3059.95**	3522.46**
	Rate of change by time	σ^2_1		**508.81****		502.00**	502.00**	418.34**
	Rate of change by age	σ^2_2			546.96**			
Pseudo R2 statistic and Goodness-of-fit								
	$R^2_{y,y}$			**0.604**	0.067	0.636	0.636	0.627
	Deviance		840.76	**714.91**	753.8	713.96	713.96	712.50
	AIC		846.76	**726.91**	765.80	727.96	727.96	726.50
	BIC		847.35	**728.09**	766.98	729.34	729.34	727.88
	# parameters		3	**6**	6	7	7	7

* $p < .05$, ** $p < .005$. Outlined cells indicate: the model selected on the basis of fit; the parameter estimates and standard errors for the predictors in that model; and the total variance accounted for by that model. The dark grey cells indicate the effects of age (an alternate measure of time), while the light grey cells indicate the effects of age at adoption.

Table D1 provides the statistical evaluation of each of these models for the infants. As Figure D1 illustrates, both time in the U.S. and age are reliable predictors, but age accounts for more variance ($R^2_{y,y}$= .44, $R^2_{y,y}$= .39, for age and time respectively) and when both are included in the model, time has no reliable effect (partial $R^2_{y,y}$< .01). In the second and third age growth models, age of adoption was added as a predictor of the intercept and the slope of the growth curve, respectively. However, it did not have a reliable effect in either case (partial $R^2_{y,y}$= .02 for both). Thus for children adopted by 16 months of age we find that vocabulary size depends primarily on the child's chronological age and not their age at adoption or the time that has passed since adoption.

The results for preschoolers are quite different (Table D2). While age and time are equivalent predictors within a subject, the parameter estimates across subjects are more stable when time since adoption is used. For this reason the $R^2_{y,y}$ value is much higher for time than for age ($R^2_{y,y}$= .60 and $R^2_{y,y}$= .07, respectively) . When both are included in the model, time since adoption continues to be highly reliable but age does not (partial $R^2_{y,y}$= .03). In the second and third time growth models age of arrival is added as a predictor of the slope and intercept, but we find no reliable effects in this small sample of preschoolers (partial $R^2_{y,y}$= .03 and partial $R^2_{y,y}$= .02, for the intercept and slope respectively). However, in a supplemental analysis that included participants who did not complete the study, there was a reliable effect of age of arrival on the slope of the vocabulary function [t(15)=2.30, $p < .05$, partial $R^2_{y,y}$= .02], with the older preschooler learning words somewhat faster than the younger ones.

These analyses suggest that the relevant measure of time is different for these populations. In the infants word learning is closely linked to biological age—a child who arrives at 15 months of age may begin speaking shortly after adoption, while one who arrives at 5 months may wait considerably longer. The preschoolers, in contrast, are ready to learn from the moment they walk off the plane, so for them vocabulary size is tightly linked to the amount of time that they have been in the U.S.

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