abstract

OBJECTIVE: To test the independent association of adult language input, television viewing, and adult-child conversations on language acquisition among infants and toddlers.

METHODS: Two hundred seventy-five families of children aged 2 to 48 months who were representative of the US census were enrolled in a cross-sectional study of the home language environment and child language development (phase 1). Of these, a representative sample of 71 families continued for a longitudinal assessment over 18 months (phase 2). In the cross-sectional sample, language development scores were regressed on adult word count, television viewing, and adult-child conversations, controlling for socioeconomic attributes. In the longitudinal sample, phase 2 language development scores were regressed on phase 1 language development, as well as phase 1 adult word count, television viewing, and adult-child conversations, controlling for socioeconomic attributes.

RESULTS: In fully adjusted regressions, the effects of adult word count were significant when included alone but were partially mediated by adult-child conversations. Television viewing when included alone was significant and negative but was fully mediated by the inclusion of adult-child conversations. Adult-child conversations were significant when included alone and retained both significance and magnitude when adult word count and television exposure were included.

CONCLUSIONS: Television exposure is not independently associated with child language development when adult-child conversations are controlled. Adult-child conversations are robustly associated with healthy language development. Parents should be encouraged not merely to provide language input to their children through reading or storytelling, but also to engage their children in two-sided conversations.

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Contributors: Frederick J. Zimmerman, PhD, a Jill Gilkerson, PhD, b Jeffrey A. Richards, MA, b Dimitri A. Christakis, MD, MPH, c Dongxin Xu, PhD, b Sharmistha Gray, PhD, b and Umit Yapanel, PhD b

aDepartment of Health Services, School of Public Health, University of California, Los Angeles, California; bDepartment of Research, LENA Foundation, Boulder, Colorado; cOutcomes Research, Children’s Hospital and Regional Medical Center, Seattle, Washington

Key Words: language development, reading, television

Abbreviations

PLS—Preschool Language Scale
CI—confidence interval

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Address correspondence to Frederick J. Zimmerman, PhD, University of California, Los Angeles, Department of Health Services, School of Public Health, Los Angeles, California. E-mail: fredzimmerman@ucla.edu

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The amount of language input a child receives before age 3 is significantly and strongly associated with subsequent language acquisition and cognitive development.\(^1\)\(^-\)\(^3\) Because of this relationship, pediatricians and others are encouraged to advise parents to provide as much language input to young children as possible, through reading, storytelling, and simple narration of daily events. Although this advice is undoubtedly sound, it may not place enough emphasis on the child's role in language-based exchanges.

The framing of advice offered to parents may differ depending on how adult speech is understood to foster child language development. If adult speech input is presented as intrinsically valuable, because it serves as a model for language that children intuitively copy, then parents can conclude that the more adult speech the better, even if some of this adult speech comes through television or videos. Many parents have drawn exactly such conclusions.\(^9\)\(^,\)\(^10\) On the other hand, if the primary value of adult speech is to potentiate child speech as part of a trial-and-error, experiential process of language acquisition, then adult speech is valuable inasmuch as it fosters child speech, and either adult speech or electronic stimulus that crowds out child speech may be counterproductive.

Heavy television viewing in the early childhood years has been shown in previous studies to be associated with poor development of language and reading and math skills, although the reasons for this adverse association are still not well understood.\(^11\)\(^-\)\(^13\)

This analysis uses a large, unique new data set of parent and child language use collected naturally in the home environment to test the independent contributions of adult language input, child language use, and television viewing on subsequent child language development among children who were between the ages of 2 and 36 months at enrollment. We hypothesized that adult speech would have a beneficial effect on child language development, but that this beneficial effect would be partially mediated by an increase in adult-child conversations.

**METHODS**

This research relies on data collected in children's own environments: homes, playgrounds, schools, and anywhere else children use or hear language. Data were collected for 12-hour periods 1 day a month for 6 months (or over 18 months in the longitudinal sample) by using a new product called LENA (Language Environment Analysis [LENA Foundation, Boulder, CO]). The hardware component is a small digital recorder called a digital language processor, which fits into a pocket on a special vest worn by the child. The digital language processor weighs 2 oz and can hold 16 hours of digitally recorded sound.\(^14\) The software component consists of a digital sound analyzer that produces estimates of the child's exposure to adult speech, child speech, and television during the recording period.

**Study Sample**

Parents of children aged 2 to 48 months were invited to participate through advertising in local newspapers and direct-mail solicitation. From among those expressing an interest, a sample was invited to participate, stratified on maternal education and the age of the child. Because the emphasis of the study was on language development, by design all but 15 of the children were aged 2 to 36 months. Children whose parents reported a developmental or language delay were excluded. Only children in English-speaking households were eligible.

Of the 364 participants invited to participate, 334 (92%) participants completed consent forms and were enrolled. During the course of the original 6-month study period, 13 participants dropped out or moved away, and final assessments could not be scheduled with an additional 8 families. Five participants were excluded because their recordings were all <12 hours in duration; 5 were excluded because their Preschool Language Scale (PLS) data were judged by raters to have poor validity; and 28 were excluded because their PLS assessments were not completed during phase 1. These exclusions left a sample of 275 (82% of those enrolled). The final sample is highly representative of the US census data with regard to maternal education.

For a randomly chosen day, parents were instructed to begin recording when their child woke up in the morning and to continue without interruption until bedtime. Parents were given the option of deleting all data on the device if they felt that anything recorded during that day compromised their privacy. Only 1 parent chose to exercise this option. Each child contributed an average of 4.7 recording sessions throughout the 6-month period.

Participants' language capacity was formally assessed by a speech language pathologist by using the Preschool Language Scale, Fourth Edition (PLS-4).\(^15\) These assessments occurred throughout the 6-month study period, with each child assessed an average of 2.3 times. A subset of 80 families, selected to be representative of the entire sample stratified by age groups, was recruited to participate in an 18-month-long continuation with the same protocol as described above. This subsample provides the opportunity to conduct longitudinal analyses and is referred
to as the “longitudinal sample” or “phase 2.” Complete data were available for 71 families in the longitudinal sample.

The recruitment strategy and study protocol were reviewed and approved by the Essex institutional review board. Additional details on the study recruitment and data-collection procedures have been published previously.

**Variables**

The dependent variable is the PLS-4, a well-validated measure of child language development in the preschool years. The PLS-4 comprehensively assesses a child’s emerging communicative capacity. It identifies ability in many domains, including gesture, social communication, language structure, phonological awareness, and attention. Test-retest reliability ranges from .90 to .97 for the summary score, and interrater reliability is .99. The age-normed summary score was used in this analysis.

Child language exposure and use as well as electronic media (hereafter, “television”) are detected by the InfoCove software's analysis of the sound files. By analyzing acoustical properties in the file, the software estimates the number of words spoken by adults, vocalizations by the key-child, child-adult conversational turns, and the amount of time the child was exposed to television. The technical details of this process have been described elsewhere.

To assess fidelity of the software, a subsample of seventy 12-hour sessions (an age-stratified random sample) were coded by human coders, and the resulting estimates were compared with those of the software. The software achieves a high degree of fidelity in coding. Cohen’s $\kappa$ of interrater agreement between the machine and human coding of segments into adult speech is 0.65; for television exposure it is 0.57. Among segments that human transcribers identified as adult speech, 82% were correctly identified as such by the software, with <2% erroneously coded as child speech, and 4% erroneously coded as television. Among segments that the software identified as adult speech, 68% were so identified by human transcribers. The full-fidelity matrix is reported in Table 1. Diagonal elements generally exceed 70%, indicating a high degree of concordance between machine and human transcribers. Where miscodings occur, they rarely involve confusion of key variables in this analysis.

Our measure of adult language input is the adult word count estimate, which measures the quantity of language input by any adult, not just the parent. The software cannot identify whether the speech was addressed to the child or not, only whether the child was near enough for it to be heard clearly.

Our measure of child speech is adult-child conversational turns, defined as the number of times that the speaker changes within a single conversation. A conversation is defined as a segment of speech of any length or number of speakers, separated by not >5 seconds of silence (or other noise, including television). For example a conversation consisting of adult-child-adult-child would include 2 conversational turns, whereas a “conversation” consisting only of adult speech would include no conversational turns. Conversational turns exhibit modest correlation with the adult word count, with a correlation coefficient of 0.55.

Television (or other electronic media) exposure is most clearly identified by the software when it is a clear part of the child’s auditory environment. The software cannot identify whether the child was attending to the television while hearing it, and as such cannot distinguish between viewing and background exposure to television, both of which degrade young children’s ability to attend to tasks or people. For the identification of television exposure, this method compares favorably to parent-report and other means of assessing child television viewing, which is notoriously difficult to measure. This ascertainment error introduces a conservative bias into the analyses that follow.

Television viewing was measured in number of hours per day, averaged over the observation periods. Exposure to adult language input was measured as the estimated number of words spoken by adults in the child’s

### Table 1: Fidelity Matrix

<table>
<thead>
<tr>
<th>Machine-Coded As:</th>
<th>Total, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adult Speech, %</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>100</td>
</tr>
<tr>
<td>Among segments human-transcribed as</td>
<td>100</td>
</tr>
<tr>
<td>Adult speech</td>
<td>82.0</td>
</tr>
<tr>
<td>Child vocalization</td>
<td>13.5</td>
</tr>
<tr>
<td>Television</td>
<td>7.8</td>
</tr>
<tr>
<td>Other</td>
<td>7.3</td>
</tr>
<tr>
<td>Specificity</td>
<td>100</td>
</tr>
<tr>
<td>Human-coded as</td>
<td>100</td>
</tr>
<tr>
<td>Adult speech</td>
<td>67.9</td>
</tr>
<tr>
<td>Child vocalization</td>
<td>2.5</td>
</tr>
<tr>
<td>Television</td>
<td>0.9</td>
</tr>
<tr>
<td>Other</td>
<td>28.7</td>
</tr>
</tbody>
</table>
near proximity. To facilitate interpretability, we rescaled this variable in thousands. Conversational turns estimates were rescaled in hundreds.

**Statistical Methods**

We conducted both cross-sectional and longitudinal regressions. In both sets of regressions, we regressed PLS-4 scores on the recorded measures of adult word count, conversational turns, and television, controlling for sociodemographic variables, including the child’s age, gender, and race, the mother's and father’s education level, and household income. Father’s education was imputed where missing, and a missing-value flag was included in the regressions. Because the main predictor variables as well as the outcome variables were measured at more than 1 time period for many participants, we averaged the measures over the number of recording sessions and included the number of sessions used to create these averages as covariates. To appropriately weight the different observations for the different number of sessions that contributed to the child averages, we used analytical weights, with the number of sessions as the weighting variable.

In the cross-sectional regressions, we regressed PLS-4 scores in phase 1 on the contemporaneously recorded measures of adult word count, conversational turns, and television. In the longitudinal regressions, we regressed phase 2 PLS-4 scores on phase 1 adult word count, conversational turns, and television, also controlling for phase 1 PLS-4 scores. Although the longitudinal analysis is the stronger study design, it also has substantially fewer participants than the cross-sectional analysis. Results from both sets of regressions are reported.

Within each set of regressions, we tested whether the effects of adult word count and television were mediated through conversational turns. Accordingly, we conducted 5 regressions within each sample set: 1 each in which the 3 main predictors were separately included; 1 in which all 3 main predictors were simultaneously included; and 1 regression of conversational turns on adult word count and television.

**RESULTS**

Table 2 presents descriptive statistics for the cross-sectional sample. Children hear an average of some 13,000 words spoken to them by adults each day. Children participate in some 400 adult-child conversational turns a day. There is considerable sample variation around these means, and in particular the variation is higher for conversational turns (for which the coefficient of variation is 54%) than for adult speech (coefficient of variation: 34%).

The independent effects of all 3 main predictors on language development are significant in the cross-sectional regressions fully adjusted for social and demographic characteristics (Table 3). Each 1000-word increase in the adult word count is associated with a 0.44 increase in the PLS-normed score (95% confidence interval [CI]: 0.09–0.79). On average, each hour of television viewing per day to which the child is exposed is associated with a...
2.68 decrease in the language score (95% CI: −5.25 to 0.11). Each hundred conversational turns per day is associated with a 1.92 increase in the language score (95% CI: 1.12–2.73).

When all 3 of the main predictors are simultaneously included in the regression, adult word count and television exposure are no longer significant, suggesting complete mediation by conversational turns, which retains its statistical significance with a slightly higher magnitude (coefficient: 2.08 [95% CI: 0.97–3.19]). In the regression of conversational turns, adult word count has a significant and positive association (coefficient 0.28 [95% CI: 0.24–0.32]), whereas television exposure has a significant and negative association (coefficient: −0.51 [95% CI: −0.79 to 0.23]).

A similar pattern obtains in the longitudinal regressions, in which phase 1 PLS-4 scores are controlled (Table 4). Adult word count is a significant predictor of subsequent PLS-4 scores (coefficient: 1.34 [95% CI: 0.59–2.10]). In this regression, unlike the cross-sectional one, the effect of adult word count is not fully mediated by conversational turns, but retains its significance and much of its magnitude. Television viewing is not a significant predictor of language development in any of the longitudinal regressions. Conversational turns is a robust predictor in the longitudinal model (coefficient: 3.33 [95% CI: 1.58–5.07]), and retains its significance and much of its magnitude in the fully saturated model (coefficient: 2.18 [95% CI: 0.18–4.18]). Adult word count predicts subsequent conversational turns (coefficient: 0.17 [95% CI: 0.06–0.29]). Phase 1 language ability is not a significant or meaningful predictor of phase 2 conversational turns.

**DISCUSSION**

The analyses presented here collectively make a strong case for the importance of adult-child conversations to early child language development. The number of conversational turns that children have with adult caregivers is robustly and positively associated with scores on a well-validated measure of child language development in a variety of model specifications.

The longitudinal results reported here, although emerging from a smaller sample than the cross-sectional results, are particularly compelling, because they control for the child’s baseline language development. This model teases apart the separate effects of a child’s own ability and a child’s conversations with others on subsequent language development.

These results are consistent with a number of causal interpretations. It might be that children who are more advanced with their language abilities are better at initiating or prolonging conversations. It could also be that there is a common but unobserved variable that causes certain children to have high language scores and to engage in a lot of conversation. The significance of conversational turns in

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**TABLE 3** Cross-Sectional Regression of PLS-4 Scores on Adult Word Count, Conversational Turns, and Television Exposure, and of Conversational Turns on Adult Word Count and Television Exposure

<table>
<thead>
<tr>
<th>Predictors</th>
<th>PLS-4 (Phase 1), Coefficient (95% CI)</th>
<th>PLS-4 (Phase 1), Coefficient (95% CI)</th>
<th>PLS-4 (Phase 1), Coefficient (95% CI)</th>
<th>PLS-4 (Phase 1), Coefficient (95% CI)</th>
<th>CT (Phase 1), Coefficient (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult word count (1000 s/d)</td>
<td>0.44 (0.09 to 0.79)a</td>
<td>−0.16 (−0.63 to 0.30)</td>
<td>0.28 (0.24 to 0.32)b</td>
<td>0.82 (0.05 to 1.60)a</td>
<td>0.03 (−0.01 to 0.06)</td>
</tr>
<tr>
<td>Television exposure (h/d)</td>
<td>−2.68 (−5.25 to 0.11)a</td>
<td>−1.4 (−3.97 to 1.14)</td>
<td>−0.51 (−0.79 to 0.23)b</td>
<td>2.08 (0.97 to 3.19)a</td>
<td>0.14 (−0.68 to 0.94)</td>
</tr>
<tr>
<td>Conversational turns (100 s/d)</td>
<td>1.92 (1.12 to 2.73)a</td>
<td>0.51 (0.06 to 1.60)</td>
<td>0.17 (0.06 to 0.29)</td>
<td>0.68</td>
<td></td>
</tr>
</tbody>
</table>

Results adjusted for child’s age, gender, race/ethnicity, mother’s and father’s education, household income, and number of recording sessions (N = 275). CT indicates conversational turns.

a P < .05.
b P < .01.

**TABLE 4** Longitudinal Regression of Phase 2 PLS-4 Scores on Phase 1 PLS-4, Adult Word Count, Conversational Turns, and Television Exposure, and of Conversational Turns on Adult Word Count and Television Exposure

<table>
<thead>
<tr>
<th>Predictors</th>
<th>PLS-4 (Phase 2), Coefficient (95% CI)</th>
<th>PLS-4 (Phase 2), Coefficient (95% CI)</th>
<th>PLS-4 (Phase 2), Coefficient (95% CI)</th>
<th>PLS-4 (Phase 2), Coefficient (95% CI)</th>
<th>CT (Phase 2), Coefficient (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1 PLS-4</td>
<td>0.46 (0.24 to 0.68)a</td>
<td>0.32 (0.10 to 0.54)a</td>
<td>0.38 (0.16 to 0.61)a</td>
<td>0.03 (−0.01 to 0.06)</td>
<td></td>
</tr>
<tr>
<td>Adult word count (1000s/d)</td>
<td>1.34 (0.59 to 2.10)a</td>
<td>0.82 (0.05 to 1.60)a</td>
<td>0.17 (0.06 to 0.29)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV exposure (foreground) (h/d)</td>
<td>−1.4 (−4.71 to 7.61)</td>
<td>−0.38 (−5.90 to 5.14)</td>
<td>0.14 (−0.68 to 0.94)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conversational turns (100s/d)</td>
<td>3.33 (1.58 to 5.07)a</td>
<td>2.18 (0.18 to 4.18)</td>
<td>0.58</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results adjusted for child’s age, gender, race/ethnicity, mother’s and father’s education, household income, and number of recording sessions (N = 71).

a P < .01.
b P < .05.
predicting phase 2 language scores even when phase 1 language ability is controlled in a longitudinal regression. This militates against such interpretations, as does the nonsignificance of phase 1 language ability in predicting phase 2 conversational turns.

Finally, it could be that the child-adult conversations are themselves causing language development. Such a causal conclusion would be consistent with several strands recently introduced in the empirical and theoretical literatures on child language acquisition. Parents are most efficient at promoting child language development when they calibrate their own speech to be just challenging enough for the child, neither so simplistic that the child learns nothing from the parent’s model, nor so sophisticated that the child is bewildered. This just-challenging zone has been termed the “zone of proximal development.” Because maintaing adult speech in the zone of proximal development depends on the adult’s being in touch with the child’s rapidly changing abilities, frequent exposure to child language through adult-child conversations may help keep the adult’s own speech in the zone of proximal development. Child language development has also been shown to benefit from active correction of errors by adult speakers. More conversations mean more opportunities for mistakes and, therefore, corrections. In addition, more conversations may afford the child more opportunity to practice and consolidate newly acquired language. Finally, more conversations may indicate more adult responsiveness to the child’s communication in general.

These results have meaningful implications. Much of the advice given to parents has focused on the value of reading to children as a way of facilitating adult language input. Indeed, reading-promotion programs on their own have been shown to produce improvements in children’s home literacy environment at very low cost. Yet the most effective reading is dialogic reading, which involves explicitly soliciting language use by the child. More generally, parents should be taught that although adult speech is valuable, an equally important goal should be to get kids talking as much as possible.

Television viewing before age 2 has previously been associated with delays in language development and poor reading skills. Television may adversely affect language development by limiting opportunities for parental language input or by limiting opportunities for child speech. Recent research has shown that although preschoolers can learn vocabulary from television, when used without parental interaction, television is an ineffective medium for inculcating language skills among infants and toddlers. When conversational turns are included in the regressions, television drops from significance, suggesting that the adverse effects of television exposure, if any, would operate by reducing opportunities for adult-child interactions.

This research leaves many important questions unanswered. We were not able to separately identify the effects of child language use and conversational turns, which were highly correlated with each other (correlation coefficient: 0.84). It will be useful in future research to tease out the independent contribution of these 2 similar factors. The novel technology used in this research clearly has tremendous promise but is not yet able to distinguish more nuanced, elements of child-adult interactions, including emotional tone, questions and responses, whether adult speech is directed to the key child or merely overheard by him or her, and other qualitative differences among dyads. Recent research suggests that children are able to learn vocabulary by overhearing adult speech and, this intriguing finding, too, suggests important new avenues for this research.

CONCLUSIONS

This research provides strong, albeit not absolute, evidence from naturalistic observations that adult-child conversations are an essential component of child language development. Parents should continue to be encouraged to provide speech input to their children by talking to them, reading them books, and by telling them stories. At the same time, it should be made clear to parents that an important goal of this talk is to elicit talk from the child. Reading and storytelling should be punctuated by questions and exchanges, and it may be appropriate to counsel parents to encourage parent-child conversations. Parents should strive to read and talk with children and not merely to them. Parent-child interactions are best when they are a two-way street.

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REFERENCES


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