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Input Subject Diversity Enhances Early Grammatical Growth: Evidence from a Parent-Implemented Intervention

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Abstract

Purpose—The current study used an intervention design to test the hypothesis that parent input sentences with diverse lexical noun phrase (NP) subjects would accelerate growth in children's sentence diversity.

Method—Child growth in third person sentence diversity was modeled from 21 to 30 months (n = 38) in conversational language samples obtained at 21, 24, 27, and 30 months. Treatment parents (n = 19) received instruction on strategies designed to increase lexical NP subjects (e.g., *The baby is sleeping*.). Instruction consisted of one group education session and two individual coaching sessions which took place when children were approximately 22 to 23 months of age.

Results—Treatment substantially increased parents' lexical NP subject tokens and types ($\eta_p^2 \geq .45$) compared to controls. Children's number of different words was a significant predictor of sentence diversity in the analyses of group treatment effects and individual input effects. Treatment condition was not a significant predictor of treatment effects on children's sentence diversity, but parents' lexical NP subject types was a significant predictor of children's sentence diversity growth, even after controlling for children's number of different words over time.

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Conclusions—These findings establish a link between subject diversity in parent input and children's early grammatical growth, and the feasibility of using relatively simple strategies to alter this specific grammatical property of parent language input.

Keywords

child-directed speech; toddlers; syntax; parent input; language intervention

Understanding how input influences children's language development is a central question in developmental psycholinguistics and the applied fields of education, speech-language pathology and early intervention. Research efforts have been successful in establishing how variation in the quantity and quality of parent language input and interaction contributes to individual differences in children's vocabulary growth (e.g., Cartmill et al., 2013; Hart & Risley, 1995; Hirsh-Pasek et al., 2015; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Rowe, 2012) and the emergence of complex sentences (Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002; Huttenlocher, Vasilyeva, Waterfall, Vevea, & Hedges, 2007; Vasilyeva, Waterfall, & Huttenlocher, 2008; Rowe, 2012). In contrast, replication of early empirical findings has been rare in studies examining the relation between grammatical properties of parent input and children's grammatical development (Valian, 1999) and fewer studies have focused on precise relations between specific measures of parent input and child language growth (e.g., Hadley, Rispoli, Fitzgerald, & Bahnsen, 2011; Hoff-Ginsberg, 1986; Richards, 1990). Yet, identification of specific links between parent language input and children's acquisition of grammar is needed to characterize the nature of underlying language learning mechanisms and to design more effective grammatical interventions.

Links from parent input to children's rate of grammatical development have been difficult to identify for many reasons. To begin, early studies explored too many parent predictors. For example, Newport, Gleitman, and Gleitman (1977) explored correlations between 10 aspects of maternal speech and four measures of child language structure and mean length of utterance (MLU). Richards and Robinson (1993) correlated 15 parent input measures and two child outcome variables at three different time points for a total of 90 correlations. When numerous correlations are computed, some findings will be significant by chance alone (Benjamini & Hochberg, 1995) and replication is less likely. Second, some input studies have characterized grammatical input too generally using only MLU. Although Rowe, Levine, Fisher, and Goldin-Meadow (2009) found that longer parent utterances were a more potent predictor of MLU growth for children with brain injury than for children without brain injury, this finding does not identify the crucial input features underlying this growth (Hoff, 2006). As such, this finding cannot be translated into guidelines for intervention. Third, few studies have tested hypotheses about how input interacts with and influences children's grammatical representations. The role of input is often conceptualized broadly as exposure to grammatical structures (e.g., Huttenlocher et al., 2007; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010); however, more complex mechanisms are almost certainly involved in learning abstract grammatical patterns (Freudenthal, Pine, & Gobet, 2010; Gomez, 2002; Thompson & Newport, 2007; Yang, 2002). Although measurement of specific grammatical structures in input may seem straightforward, the extent to which children make use of input data is more complicated. That is, some grammatical structures in the input may be "filtered out" by the internal state of the learner's developing grammar, language processing systems, or extralinguistic systems such as attention or memory (see Lidz & Gagliardi, 2015). This possibility makes it more challenging to identify how grammatical properties of parent input influence children's grammatical development. Finally, most input studies are correlational, and therefore, causal interpretations of findings are tenuous. Studies that manipulate properties of parent input through intervention designs provide a stronger basis for explaining how input properties influence grammatical development. To date, parent-implemented language intervention studies have focused primarily on input properties that facilitate vocabulary development, utterance length, and accurate use of grammatical morphemes (see Roberts & Kaiser, 2011 for a recent meta-analysis). In contrast, the way in which input properties facilitate children's first sentences has been largely overlooked.

The purpose of this study was to teach parents simple strategies intended to modify structural information in their input sentences that would, in turn, facilitate children's growth in sentence diversity. We operationalized sentence diversity as lexical flexibility with basic clause structure, specifically unique combinations of subjects and verbs. We focused on the subject-predicate relationship for several reasons. First, adult sentences consist minimally of two constituents, a subject noun phrase (NP) and verb phrase (VP). Therefore, we conceptualized children's ability to produce sentences with increasingly diverse combinations of subjects and verbs over time as an indicator of developmental progress toward adult grammatical productivity (Ingram, 1989; Naigles, Hoff, & Veer, 2009). In addition, the subject-predicate relationship is the fundamental component of hierarchically organized clause structure, reflecting the merge of verb phrase (VP) into Tense Phrase (TP) (Chomsky, 1995).

To learn basic clause structure, children must discover that words are grouped into constituents and the position of the subject constituent relative to the predicate. Natural languages expose children to multiple, correlated cues for identifying phrase structure. For example, prosodic cues such as syllable lengthening, pausing, and pitch changes at phrasal boundaries help children identify phrases (Fisher & Tokura, 1996). Natural languages also contain single word pro-forms that can be substituted for a group of words or can express similar meanings with alternative ordering of constituents; these cues to phrase structure exist across sentences in discourse (Morgan, Meier, & Newport, 1989). Using an artificial miniature grammar learning paradigm, Morgan et al. (1989) demonstrated that adults showed enhanced learning of complex syntactic rules when input sentences contained cross-sentential cues compared to input sentences without such cues. They proposed pronominalization or moved phrases may make the phrasal units of sentence structure more prominent to the learner, especially when presented in successive utterances such as: *I see your ball. It rolled under the table. Under the table, it rolled*. Compatible findings have also been documented in studies of parent-child interactions. For example, Hoff-Ginsberg (1985) found that adjacent maternal utterances that added or deleted whole constituents or replaced NPs with pronouns facilitated children's growth in the number of verbs per utterance two months later. Hoff-Ginsberg (1985, 1986) hypothesized that adjacent utterances with syntactically similar, but not identical, structural information supported the identification of constituent structure by facilitating distributional analysis.

More recently, Thompson and Newport (2007) revisited the question of what cues were available to help children learn phrase structure. They hypothesized that learners could use differences in the transitional probabilities between successive elements to detect constituent boundaries; higher predictability between successive elements was expected to signal a phrasal grouping whereas lower predictability between elements was expected to signal a phrasal boundary. They tested this hypothesis with adult learners using an artificial miniature grammar. Thompson and Newport created a control condition in which the transitional probabilities between successive elements were equal. They also created experimental conditions based on phenomena occurring in natural languages, specifically optional phrases, repeated phrases, moved phrases, and different-sized form classes within phrases. Thompson and Newport found significantly better learning of phrasal boundaries in the optional phrase, repeated phrase, and moved phrase conditions than in the control condition. The best learning occurred when all experimental conditions were combined. They interpreted this pattern of results as evidence that learners grouped words into constituents and computed the transitional probability cues to constituents rather than for individual words.

In this study, we hypothesized that increasing the number of third person lexical NP subjects (e.g., *the pig; your tower*) in parent input sentences would help children identify the subject NP as a separate constituent from the VP, strengthening their representation of the subject/predicate relation in the mental grammar. A stronger representation of the subject/predicate relation should enable children to generate more diverse subject-verb combinations in the real-time act of sentence production. We expected the input modification to have these effects for several reasons. Extending the findings of Thompson and Newport (2007) to natural language learning, we reasoned that parent input samples with low-frequency lexical NP subjects would have lower transitional probabilities at the subject-predicate boundary compared to input samples with primarily high-frequency, pronominal subjects (e.g., *it, that, you*). That is, input with lower-frequency nouns in the subject position would accentuate the transitional probability cues for identifying subjects and predicates as separate constituents. Additionally, input sentences with lexical NP subjects might better align prosodic cues with the subject and predicate constituents. This is because sentences with longer subjects are more likely to be followed by uncontracted copula and auxiliary forms than those with pronominal subjects (Frank & Jaeger, 2008).

To test our hypothesis, we developed *toy talk* (Hadley & Walsh, 2014) to increase children's exposure to sentences with lexical NP subjects. Toy talk is taught to parents using two simple strategies: (a) *talk about the toys* the child is playing with, and (b) *give the object its name* (e.g., *The tower fell*. NOT *It fell.*). When these strategies are combined, the frequency and diversity of lexical NPs as subjects in parent input are expected to increase. Toy talk should be recognized as a special type of descriptive commenting. It is similar to self-talk (i.e., talk about one's own actions; *I'm feeding the baby.*), parallel talk (e.g., talk about child's action; *You're feeding the baby.*), and responsive labeling (e.g., *That's a monkey.*) in matching the content of language input to children's interests and activities. However, primary use of self-talk, parallel talk, and responsive labeling may inadvertently reduce grammatical subjects in the input to a small set of closed-class, pronouns (e.g., *it, that, I, you*); this may be less optimal for identifying the phrasal status of the subject constituent.

Toy talk is intended to be used in responsive conversational interactions. Responsive interaction strategies include following the child's attentional lead, interpreting communicative attempts, and expanding single words into phrases and sentences (Bunce, 1995; Girolametto, Pearce, & Weitzman, 1996; Girolametto & Weitzman, 2006; Justice, Mashburn, Pence, & Wiggins, 2008; Roberts & Kaiser, 2011, 2012; Robertson & Ellis Weismer, 1999). Instruction emphasized ways to expand children's utterances with a toy talk sentence (e.g., Child: *sleep* → Adult: *The baby is sleeping*. Child: *it fall* → Parent: *The cup fell.).* Thus, we built toy talk instruction on the foundation of responsive interaction strategies and descriptive commenting. By doing so, we expected lexical NP subjects to bring stronger transitional probability cues together with prosodic and cross-sentential cues to make the subject-predicate constituent boundary in parent input more prominent to the learner.

In an initial feasibility study, Hadley and Walsh (2014) instructed college students to "talk for the parent" while watching silent video clips of parent-toddler play before and after 20-min of toy talk instruction. Following instruction, the college students increased use of sentences with lexical NP subjects and decreased use of sentences with second person *you*-subjects. Significant increases were also observed in the proportion of verb forms overtly marked for tense and agreement in the input sentences without any instruction on tense/agreement morphemes. Although this study demonstrated that toy talk instruction changed adult use of lexical NP subjects and tense/agreement morphemes, it was not clear if parents could learn the strategies with brief instruction and use them in naturally occurring conversations with their toddlers.

The current study addressed this empirical gap with two related research questions. The first question explored the efficacy of our instructional strategies. We examined whether parents who received brief instruction in toy talk used more declaratives with lexical NPs in subject position than parents who did not receive the instruction. The second question examined whether change in this property of parent input accelerated children's growth in sentence diversity between 21 and 30 months of age. We focused on the developmental period from 21 to 30 months of age because most children begin producing telegraphic subject-verb and subject-verb-object sentences by 30 to 32 months of age (e.g., *that fall; baby sleep; I see you; Daddy fix it*; Klee & Gavin, 2010; Lee, 1974).

Method

Design—A quasi-experimental design was used to evaluate the feasibility and early efficacy of the parent-implemented intervention on children's growth of sentence diversity. Parent-toddler dyads were recruited for a treatment group who received instruction in the parent-implemented intervention. A control group was formed from an existing longitudinal database (Rispoli & Hadley, 2013). Following Fey and Finestack's (2009) 5-phase model for scaling up language intervention research, the use of an archival control group was an appropriate and cost-effective design element for an early efficacy study.

Participants—Treatment families were recruited from English-only speaking households in Champaign County, Illinois and surrounding counties, following the same strategies used for the control group. Information was distributed to parents through newspapers, community facilities and list-serves. The principal investigator (PI) arranged phone interviews with interested parents. The interview was designed to identify monolingual families with typically developing toddlers who were rarely or not yet producing sentences. Children were excluded if parents reported neurological or sensory impairments, delayed onset of walking/talking, or regular exposure to a language other than English. Children were also excluded if parents reported use of 4-word combinations, consistent with expressive abilities that were likely to be too advanced for the intervention. Production of at least one 4-word combination would place a child's expressive language abilities above the 70th percentile on the *MacArthur-Bates Communicative Development Inventory* (CDI) for the mean three longest sentences (i.e., > 3.0 at 20 months both sexes; Fenson et al., 2007). To be included, children were required to pass the communication section of the *Ages and Stages Questionnaire-3* (*ASQ-3*; Squires & Bricker, 2009) administered as part of the phone interview at 20 months of age. Parents were also asked whether their children produced at least 25 different words. This corresponded to expressive abilities at approximately the 10th percentile on the CDI for total words (i.e., 10th percentile at 20 months both sexes = 29 words). If children met these criteria, families were invited to participate. Families received $15 for each visit to complete all parent report tools and to compensate them for their time and travel. Parents also received a parent education resource (Manolson, Ward, & Dodington, 2007) and a toy set to support carryover of the language facilitation strategies to the home environment. Twenty children were recruited for the treatment group and matched to 20 children from the archival database on CDI total words at 21 months of age, the initial measurement point. When possible, children were also matched for sex and parent level of education. Two children, one from each group, produced five or more sentences with third person subjects at 21 months, and were excluded from subsequent data analysis, resulting in 19 parent and child participants in each condition.

All families in the treatment group were White, non-Hispanic (n = 19). The mean age of parent participants (17 mothers, 2 fathers) was 34.94 (SD = 5.19) and their highest educational levels included associate's degree or some college (n = 1), bachelor's degree (n = 7), and advanced degree (n = 11). The mean CDI total for the children (11 girls, 8 boys) at 21 months was 120.94 (SD = 63.00). Nine children were first born, nine were later born, and one was a twin. Seven children were in child care 5 hours or less per week, four were in child care 6 to 29 hours per week, and eight were in child care 30 or more hours per week.

In the control group, the majority of families were also White, non-Hispanic (n = 15). One family was White Hispanic and three families were Black. The mean age of the parent participants (18 mothers, 1 father) was 30.05 (SD = 4.38) and their highest educational levels were high school (n = 1), associate's degree or some college (n = 3), bachelor's degree (n = 11), and advanced degree (n = 4). The mean CDI total for the children (9 girls, 10 boys) at 21 months was 120.31 (SD = 56.65). Ten children in the control group were first born, eight were later born, and one was a twin. Eight children were in child care 5 hours or less per week, five were in child care 6 to 29 hours per week, and six were in child care 30 or more hours per week.

Procedures—The parent instructional component involved three parent education sessions. Parents were informed as part of the consent procedures that the same parent was required to participate in all education sessions and all measurement sessions when their children were 21, 24, 27, and 30 months old. Parents attended one group education session and two individualized parent-child coaching sessions between the 21- and 24-month measurement sessions. The parent education sessions were scheduled over a 4 to 6 week period, with each session approximately 2 to 3 weeks apart. Six spouses also attended the parent education session. The number of parents attending education sessions ranged from 1 to 4, *M* = 2.6.

The parent education session was divided into three segments. Information on language development between 18 and 30 months was presented in the first segment, including characteristics of single word users, verb users/word combiners, and childlike sentence users. Parents practiced categorizing child utterances as word combinations, verb combinations, *I*-sentences, and other-sentences (Hadley, 2014). In the second segment, the investigators presented information on responsive interaction strategies, using the *You Make the Difference* parent resource (Manolson et al., 2007) and instructional videos. Parents watched and discussed selected video clips related to the first four chapters. In the final segment, the investigators introduced the toy talk strategies using handouts (Hadley & Rispoli, 2015) and demonstrations. Parents also practiced the toy talk strategies in role-play with the investigators and received feedback. In response to parent needs and questions, some instructional components were revised after the first four education sessions. More explicit emphasis was placed on using simple, well-formed sentences and balancing conversational turns. More opportunities to practice the toy talk strategies during role plays were also provided. Additional information about the parent education is available from the first author by request.

Each coaching session began with a brief review of the responsive interaction and toy talk strategies. Parents described their use of the two types of strategies in the home. This discussion was followed by 20 min of parent-child free play, as parents played with their children and used the strategies (see *Language Samples* section for playroom description). The first 10 min of parent-toddler free play was videorecorded and burned to a digital versatile disc (DVD). An investigator replayed the videorecording on a laptop computer for the parent, pausing the video approximately once each minute to identify positive opportunities of parents' strategy use. Parents were also encouraged to pause the video to self-identify strategy use. Investigators provided feedback and suggestions for alternative comments. The investigator concluded each coaching session with an oral summarry of 2 to 3 specific suggestions to practice at home. A written summary was sent by email after the session.

Treatment Fidelity—All sessions were video-and audio-recorded to monitor treatment fidelity and timing information was used to determine the amount of time dedicated to instructional content. In the group education session, the average time spent on each segment was as follows: introductions and information about language development, 17 min 48 sec (*SD* = 3:53); responsive interaction strategies, 41 min 45 sec (*SD* = 7:31); toy talk strategies, 25 min 47 sec (*SD* = 4:48). In the coaching sessions, discussions of responsive interaction strategies averaged 3 min 11 sec (*SD* = 2:22) and toy talk strategies averaged 2 min 21 sec (*SD* = 2:23).

To assess the delivery of instructional components during the group education, two RAs who had not conducted the sessions completed a treatment fidelity checklist independently to identify the presence/absence of 20 key instructional components (available from first author upon request). Point-by-point interobserver agreement was 95% (*SD* =5.27%) for the 10 group sessions. Following the program revision, raw scores for treatment fidelity averaged 19.83 out of 20 possible items or 99.15% (range = 95% to 100%). Finally, the video feedback portion of each coaching session was transcribed and coded to determine the number of times the investigator provided feedback to the parent and the content of the feedback. On average, investigators stopped the 10-min videorecording 10.3 times (Range = 3 to 16) to provide opportunity for reflection, discussion, and feedback, and made additional comments without stopping the videorecording another 6.7 times (Range = 0 to 23). Transcripts of the coaching sessions were coded for investigator reference to specific strategies including child-centered and interaction promoting strategies, general language modeling strategies, and toy talk strategies. Investigator feedback on use of simple, well-formed sentence input was coded separately. Discussion of sentence input and toy talk strategies comprised 33% and 24% of the total video feedback provided to the parents, respectively. Other strategies commonly discussed included comment (8%), expand (7%), wait (7%), join-in (6%), and interpret (5%). The most common suggestions appearing in email correspondence were toy talk strategies (23%), sentences (18%), expand (14%), and comment (12%).

Language Samples—Parents' use of toy talk and children's early grammatical growth were obtained from measurement sessions when children were 21, 24, 27, and 30 months of age. Language samples were gathered in a sound-treated playroom using three sound-field microphones and a wireless lapel microphone in a vest worn by the child to create high quality compact disc (CD) recordings. Two digital pan-tilt-zoom cameras recorded the nonverbal interactive context on DVD.

The play sessions were divided into two sampling contexts, matching the procedures used to collect language samples for the control group (see Hadley, Rispoli, Holt, Fitzgerald, & Bahnsen, 2014). The first context included 30 min of parent-child free play with age appropriate toys. Toys available included bubbles, puzzles, a play farm with farmers and animals, and a tower arrangement of building blocks with penguins and a ball, and a play kitchen with stove/oven, sink, cupboards, and a table with two place settings. A large Winnie the Pooh was seated at the table, along with a doll in a high chair. Additional toys were available in cupboards and closets including food, pots, pans, another doll, a bath set, a stroller, a crib, Potatohead pieces, and wind-up toys. Parents were told their children could explore the room and play with any of the toys available. Parents were encouraged to play with their children "as they would at home." The use of identical toys and set-up allowed for direct comparisons between the treatment and quasi-control groups. Although the implicit assumption at 24, 27, and 30 months was that parents in the treatment condition would use the responsive interaction and language modeling strategies they had been taught, investigators did not discuss these strategies or remind parents to use the strategies before the measurement sessions were recorded.

During the second sampling context, an investigator joined the parent-child dyad and used semi-structured play scenarios and toy talk strategies to create opportunities for diverse lexical verbs, sentence subjects, and tense/agreement morphemes (see Hadley, 2014; Hadley et al., 2014; Oetting & Hadley, 2009 for discussion). The investigator's primary goal was to shift the discourse to increase the opportunities for children to produce sentences with different third person subjects and verbs. Because parents in the control condition did not receive instruction in talking about the toys' actions, states, and properties, this design element ensured children in the control condition had ample opportunity to produce these types of sentences. Parents were encouraged to continue interacting with their children after the investigator joined the dyad; however, parents varied in their response to the investigator's presence. Therefore, only the 30 min parent-child context was used to compute parent input measures.

Transcription—To protect against investigator bias, transcription was completed by a team of undergraduate RAs who were unaware of the research questions. All transcribers completed a training program before transcribing actual data. Child transcription training emphasized issues of intelligibility, identification of names as addressee terms versus sentence subjects (e.g., *Mommy, eat it*), and detection of the presence or absence of bound morphemes and closed-class function words. Adult transcription training focused on segmentation of utterance boundaries and the presence or absence of copulas/auxiliaries in yes-no questions (e.g., *Are you coming*? vs *You coming*?). All sessions were transcribed from digital audiofiles using *Systematic Analysis of Language Transcripts* conventions (SALT; Miller & Iglesias, 2012).

Each session was assigned a unique session number so transcribers could not identify children from previously transcribed sessions. All quasi-control group sessions were re-transcribed. Sessions were sent to the unbiased transcription team in 20 blocks of 8 sessions each. Each block contained sessions from multiple measurement points, balanced for treatment condition. Approximately 16% of each sample (i.e., 5 min of each 30-min parent sample for adult utterances; 10 min of each 1-hr sample for child utterances) was randomly selected and transcribed independently by a second transcriber. If independent reliability was unacceptable (< 80% child, < 90% adult), a consensus pass was completed with digital video files.

Adult Input Measures—Parent input measures were of primary interest pre- and post-instruction (i.e., 21- and 24-months). All child-directed, spontaneous, complete, and intelligible parent utterances in the first 30 min of the parent-child sampling context were coded. Three general input measures were computed for descriptive purposes (Hadley et al., 2011; Hoff & Naigles, 2002; Huttenlocher et al., 2007): (a) number of utterances (Utt), (b) number of different words (NDW), and (c) MLU in morphemes.

To determine if the instruction resulted in differences between parents in the treatment and control groups, each parent utterance was examined for use of toy talk strategies. Toy talk

[TT] was operationally defined as a sentence (or finite clause) in which the predicate described a referential subject's state, property, action, location, or possession. Thus, an explicit subject and predicate were both required. Toy talk was only coded in finite main or embedded clauses with canonical subject-verb-(object) word order such as declarative statements (e.g., *The bubbles made a mess. I believe the piece goes right there.*) or discourse questions with no structural movement (e.g., *The egg is hot?*). In addition, the referent for the 3rd person subject was required to be present in the playroom or part of the pretend play (e.g., {mm} *This soup tastes good*). A variety of predicates met the definition of toy talk, including: states (e.g., *X tastes good. X doesn't work.*), actions (e.g., *X is sleeping. X popped.*), properties (e.g., *X is cute. X are hungry.*), possession (e.g., *X is mine.*), location (e.g., *X is over there. X is under the table.*), or relationship (e.g., *X is a baby. X are not food.).* Toy talk utterances were further classified on the basis of the grammatical subject with pronominal subjects coded as [TT:P] (e.g., *It goes in there. She's sleeping*) and lexical NP subjects coded as [TT:NP]. Lexical NP subjects could be either common nouns (e.g., *The baby needs a bath.*) or proper nouns (e.g., *Pooh likes honey.*)

Toy talk was not coded in structural questions (e.g., *Is it hot?*), embedded wh-finite clauses (e.g., *I wonder where he is*), sentences with locative movement (e.g., *Here it is. Down it went.*), gerunds as subjects (i.e., *Cooking is fun.*), or parent utterances that referred to a general activity rather than a physically present referent (i.e., *That's fun.*). Parent utterances that named the referent (e.g., *that's a cow; here's a cup*) were coded as Labeling [Lab] insofar as these utterances provided the child with a name for the toys/items; however, these utterances did not meet the operational definition of toy talk because they did not describe an action, state or property of the toy/item. See the Appendix for examples of parent utterances coded as toy talk and labeling as well as parent utterances that did not receive any code.

Child Outcome Measures—To assess developmental status and language growth, general language measures and specific measures of sentence diversity were obtained from the language samples at 21-, 24-, 27-, and 30-month measurement sessions. General measures of children's language abilities included the number of different words produced and MLU from the 30-min parent-child language sample. The measures of sentence diversity were based on the two sampling contexts combined or 60-min of conversational interaction.

Children's declarative statements and structural questions were coded for sentence diversity (Hadley, 2006, 2014; McKenna, 2013). Each sentence coded was required to contain an explicit subject and a lexical verb predicate in a finite clause context. Explicit subjects included lexical nouns, noun phrases, or pronouns. Imperatives with understood "you" subjects were not counted. Subject type codes consisted of: [SV:1] for first person singular subjects, [SV:2] for second person singular subjects, [SV:3] for third person singular subjects (lexical or pronominal), [SV:1P] for first person plural subjects, and [SV:3P] for third person plural subjects. Routine questions (e.g., *Where NP go/going?* or *What NP do/doing?*) were coded with [SV:RQ] and sentences that included the conversational partner as the grammatical subject (e.g., *Mommy*) were coded [SV:P]. These two sentence types were excluded from sentence diversity analyses because of the ambiguity of the subject role. That is, routine questions have the potential to be formulaic (Miller & Chapman, 1981), and it is often challenging to determine whether a partner name is used as an addressee term or a sentence subject.

To quantify developmental change in sentence diversity, we adapted Ingram's (1989) measure of unique syntactic types, identifying the number of unique subject-lexical verb combinations with third person subjects. Third person sentences were of primary interest because they allow lexical flexibility of both subjects and verbs, and third person subjects can appear as either pronouns or expanded NPs. In contrast, first and second person singular sentences do not allow lexical flexibility of subjects and cannot be expanded. Children were credited for each unique combination of a third person subject and verb. Singular and plural third person subjects were counted as different subject types. Children were also credited with a unique combination if the same grammatical subject was used with different verbs (e.g., *baby drink; baby cry*) or the same verb was used with different grammatical subjects (e.g., *baby eat* vs *Pooh eat*).

Reliability

Average independent transcription reliability was 95.0% (SD = 3.2%) for adults and 82.1% (SD = 11.1%) for children. Adult transcription reliability fell below the 90% criterion only 5 times when a parent spoke very quietly or very rapidly. Child transcription reliability improved with age, as children talked more and general intelligibility improved. At 21 and 24 months of age, transcripts for 20 and 17 children required a consensus pass, respectively, whereas 9 transcripts required a consensus pass at 27 and 30 months of age.

Twelve transcripts (6 treatment, 6 control), or 15% of the data, were randomly selected and coded independently for adult toy talk by a second RA. Coders were required to make decisions about whether an utterance was coded as TT:NP, TT:P, Labeling, or received no code. Cohen's kappas ranged from .88 to .99, with a mean of .95. These kappas exceeded .80, the levels of agreement conventionally considered to be acceptable (Sprent & Smeeton, 2001).

Independent reliability was also conducted for the coding of children's sentence diversity. Sentence diversity was independently coded by a second RA for six randomly selected child participants (15%) at 21, 24, 27, and 30 months. Agreement was computed for [SV:1], [SV:2], [SV:3], [SV:1P], [SV:3P], and excluded SV types combined. A total of 618 child subject-verb codes were compared, resulting in a Cohen's kappa of .94.

Data Analysis

To address the first research question, we examined change in parents' use of toy talk as a function of Condition (Treatment vs Control) before and after instruction. Repeated measures analyses of variance (ANOVA) were used with Condition as a between-subjects factor and Time as a repeated measure. An interaction effect was expected with parents in the treatment group demonstrating more use of toy talk than the control group following instruction.

For the second research question, hierarchical linear modeling (HLM) was used to analyze developmental change in third person sentence diversity and determine whether treatment accelerated growth in sentence diversity from 21 to 30 months (Holt, 2008: Raudenbush & Bryk, 2002; Raudenbush, Bryk, & Congdon, 2007). Equations were age-centered at 27 months to determine whether Condition had an effect on children's rate of growth following the instructional period. When applied to the study of longitudinal change, HLM modeling involves two levels of analysis: (a) an individual growth model that represents changes in each child's score over time, and (b) a between-child model that represents differences in the children's growth trajectories. Once the best fit growth model was determined, a random slopes model was fit to allow sentence diversity growth trajectories between 21 and 30 months to randomly vary across participants. Consequently, the estimated growth trajectory for the full group of 38 participants was determined, as well as the individual differences from the overall growth trajectory. *Treatment effects* would be evident if sentence diversity growth rates differed substantially between the treatment group and the control group.

Results

Treatment Effects on Parent Language Input

Our first question focused on changes in parent language input following brief instruction in responsive interaction strategies, in general, and use of toy talk strategies, in particular. Table 1 reports descriptive statistics for the parent language input measures by group prior to and following instruction. Prior to instruction when children were 21 months of age, there were no group differences in parent language input measures. There were no group differences in the number of utterances, utterance length or lexical diversity, all $t \leq 0.61$, all $p \geq .55$. Parents in the two groups also produced input utterances characterized as labeling or toy talk with similar frequency, all $t \leq 1.28$; $p \geq .21$. For both groups, toy talk sentences with lexical NP subjects made up only a small fraction of the total parent utterances, less than 3% in both groups.

Toy talk instruction was predicted to increase declarative sentences with lexical NP subjects in parent input. For the treatment group, toy talk with lexical NP subjects increased from a pre-instructional mean of 9.63, $SD = 6.07$ to a post-instructional mean of 40.05, $SD = 22.27$, characterizing approximately 10% of all input utterances. This reflected a change in the rate of exposure from once every 3 minutes to once every 45 seconds. In addition, parents in the treatment group produced more diverse lexical NP subject types, with the number of different nouns in subject position increasing from 5.58, $SD = 2.84$ to 18.05, $SD = 9.99$. In contrast, toy talk with lexical NP subjects did not change for parents in the control group. The mean frequency of toy talk with lexical NP subjects was 7.32, $SD = 5.09$ at the 21-month measurement point and 10.05, $SD = 7.25$ at the 24-month measurement point. Parents in the control group also produced fewer different nouns in subject position, producing 4.68, $SD = 3.04$ and 6.00, $SD = 2.96$ at 21- and 24-months, respectively. As predicted, the repeated measures ANOVA for toy talk with lexical NP subjects revealed a significant main effect for Condition, $F(1,36) = 27.28$, $p < .001$, a significant main effect for Time, $F(1,36)=42.25$, $p < .001$, and a significant Time X Condition interaction, $F(1,36) = 29.45$, $p < .001$. The same pattern of results was observed for the number of different lexical NP types (see Table 2). Effect sizes for lexical NP subjects and lexical NP types were large, $\eta_p^2 \geq .45$, indicating that the results are also practically relevant.

Differences in parent talkativity and parent education did not influence use of lexical NP subjects. Because parents who produced more total utterances might have had more opportunities to produce lexical NP subjects, we examined lexical NP use as a function of talkativity. The number of total parent utterances for the combined sample ($n = 38$) was examined at baseline and then the sample was divided into three groups at the 33rd and 67th percentiles to create a new between-subjects factor. The average parent in our high talkativity group produced 498.33 (SD = 39.64) utterances in 30 min, almost twice as many utterances as the average parent in our low talkativity group who produced 268.15 (SD = 60.11) utterances in 30 min. Parents in the average talkativity group produced an average of 406.85 (SD = 20.70) utterances in 30 min. However, parent talkativity had no effect on the changes observed in lexical NP subjects. We also examined whether there were differences in parent use of lexical NPs as a function of education level (i.e., bachelors degree or less, $n = 23$ vs advanced degree $n = 15$). Parents' use of lexical NP subjects did not differ between educational levels.

Significant Time X Condition interactions were not apparent for any other variable. For labeling, the repeated measures ANOVA revealed no significant main effects for Condition or for Time and no significant Time X Condition interaction effect. The repeated measures ANOVA for toy talk with pronominal subjects showed a significant main effect for Time only, $F(1,36) = 7.81$, $p = .008$, but no significant main effect for Condition, nor a Time X Condition interaction. The same pattern of results was observed for parents' utterance length and lexical diversity. These findings indicated that parents in both groups produced longer and more lexically diverse utterances and more declarative sentences with pronominal subjects over time.

In summary, toy talk instruction achieved its intended effect, resulting in predictable and precise changes parent input. That is, toy talk instruction substantially increased parents' use of, and children's exposure to, low-frequency lexical NP subjects in declarative sentences without altering other general properties of parent input such as utterance length, lexical diversity, labeling, and declarative sentences with pronominal subjects.

Growth in Children's Sentence Diversity

Descriptive statistics by measurement point are reported in Table 3 for children's number of different words (CNDW), verb diversity in first person singular sentences, and third person sentence diversity. Children's number of different words was based on 30 min of parent-toddler interaction only whereas the diversity measures in sentences were based on 30 min of parent-toddler interaction and 30 min of examiner-toddler interaction. The 30 min of examiner-toddler interaction was intended to shift the discourse topics in ways that would enable children to produce more diverse sentences if they were able to. There were no significant group differences for any of the descriptive variables, although differences in CNDW approached significance ($t = -1.77$, $p = .09$). As can be seen, the average CNDW, verb diversity in first person sentences, and third person sentence diversity increased steadily from 21 to 30 months. Individual variation also increased for nearly all measures in every 3-month interval.

Developmental change in sentence diversity was modeled according to Equation 1. In this equation, *Sentence Diversityti* is the observed score on child sentence diversity for child *i* at *t* months, and e_{ti} is the deviation of child *i* from his or her growth trajectory at time *t*. The e_{ti} are assumed to be normally distributed with mean 0 and variance σ^2. The parameter, π_{0i}, represents the status of child *i* at 27 months (the centering point), and π_{1i} is the linear rate of change for individual *i* at the centering point of 27 months, alternately interpreted as the instantaneous rate of linear change at 27 months. The quadratic growth parameter, π_{2i}, reflects the curvature or acceleration/deceleration in each child's overall growth across time. Larger positive values of π_{2i} imply more rapid growth in sentence diversity. Successive models were compared to one another to determine the best fit to the data. Using likelihood ratio tests, the deviance of each successive growth model was compared to the more restricted model. These tests were conducted using full information maximum likelihood (FML) estimation.

$$\begin{aligned} Sentence\ Diversity_{ti} &= \pi_{0i} + \pi_{1i}(age_{ti} - 27) + \pi_{2i}(age_{ti} - 27)^2 + e_{ti} \\ \pi_{0i} &= \beta_{00} + r_{0i} \\ \pi_{1i} &= \beta_{10} + r_{1i} \\ \pi_{2i} &= \beta_{20} + r_{2i} \end{aligned} \qquad (1)$$

A linear growth trajectory was examined first. The estimates indicated that the fixed linear coefficient and the between-child variability in linear growth were both statistically significant (see Model 1a, Table 4). That is, the linear increase in the sentence diversity score was significantly different from 0, $b_{10} = 1.30$, $p < .001$, 95% CI [1.02, 1.58], indicating growth of 1.30 unique combinations of third person subjects and lexical verbs per month, with significant variability in linear growth among children (i.e., VAR(r_1) = 0.54). The intercept was also significantly different from 0, $b_{00} = 6.89$, $p < .001$, 95% CI [5.49 , 8.30] indicating a significant difference in sentence diversity at 27 months for the group as a whole, with significant variability in the intercept remaining among children (i.e., VAR(r_0) = 15.71).

Next, a quadratic model was fit to the data to model any change in linear growth occurring over time. A likelihood ratio test indicated that the quadratic model was a significantly better fit to the data than the linear model, $\chi^2(4) = 46.00$, $p < .001$. Additionally, the test of the homogeneity of variance in the residuals was no longer significant in the quadratic model $\chi^2(34) = 24.04$, $p > .5$. These findings indicated that a quadratic model was the optimal model to characterize growth in children's sentence diversity over time.

The quadratic model had a statistically significant intercept, indicating that the number of diverse sentences was significantly different from 0 at 27 months, $b_{00} = 5.81$, $p < .001$, 95% CI [4.46, 7.16], a statistically significant linear term, indicating that the linear growth rate at 27 months was significantly different from 0, $b_{10} = 1.59$, $p < .001$, 95% CI [1.21, 1.97], and the quadratic trajectory from 21 to 30 months was also statistically significant, $b_{20} = 0.11$, $p < .001$, 95% CI [0.05, 0.17] (see Model 1b, Table 4). Together, these coefficients indicated the children in this sample produced an average of five to six different combinations of third person subjects and verbs at 27 months, with production of these different combinations increasing each month and accelerating over time. There was also significant variability in this growth pattern. All three growth components displayed significant variation among children: for intercept, VAR(r_0) = 14.63, p < .001, linear growth, VAR(r_1) = 1.16, $p < .001$, and quadratic growth, VAR(r_2) = 0.02, $p < .001$, respectively.

Treatment Effects on Children's Growth in Sentence Diversity

To control for the potential influence of initial expressive vocabulary abilities on treatment outcomes, child number of different words at 21 months (*CNDW21)* was added to the quadratic model, prior to testing for group treatment effects. Because group differences in children's number of different words approached significance at the 21-month measurement point, *CNDW21* was grand-mean centered and added to the level-2 model to control for initial differences in lexical diversity that could account for between-child differences in sentence diversity growth trajectories. All growth parameters remained statistically significant with *CNDW21* in the model (see Model 2a, Table 4). *CNDW21* was a significant predictor of children's linear growth in sentence diversity at 27 months, b_{11} .= .03, $p = .035$, and it approached significance for the intercept, $b_{01} = .10$, $p = .051$. The inclusion of *CNDW21* explained an additional 11.4% and 12.5% of the variance in between-child variation in intercept and linear growth in sentence diversity at 27 months. In contrast, *CNDW21* was not a significant predictor of quadratic growth ($b_{21} = .003$, $p = .20$). Significant variability remained among children in Model 2a, with significant between-child variation, for intercept VAR(r_0) = 12.97, p < .001, linear growth VAR(r_1) = 1.02, $p < .001$ and quadratic growth VAR(r_2) = 0.02, $p < .001$, respectively.

Finally, to test for treatment group differences in children's sentence diversity growth rates between 21 and 30 months of age, *CONDITION* was added to the Level 2 Model (see Equation 2), where $CONDITION_i$ takes on a value of 0 if child i is in the control group and 1 if child i is in the treatment group. In Equation 2, β_{00} represents the expected status at 27 months for children in the control group with an average *CNDW21* and β_{01} captures the relationship of this control variable to sentence diversity for the control group and β_{02} is the expected difference at 27 months between treatment and control children, controlling for *CNDW21*. Likewise, β_{10} represents the expected rate of change for growth in sentence diversity for the control children with an average *CNDW21*, β_{11} represents the relationship of *CNDW21* with linear change in sentence diversity at 27 months for the control group, and β_{12} captures the expected differences in rates of growth between the treatment and control children, controlling for *CNDW21*. β_{20} represents the expected acceleration for growth in sentence diversity for the control children, controlling for *CNDW21*, β_{21} captures the expected relationship of *CNDW21* with sentence diversity acceleration for the control group, and differences in acceleration between the treatment and control children, controlling for *CNDW21* are captured in the estimate of β_{22}.

$$Sentence\ Diversity_{ti}=\pi_{0i}+\pi_{1i}(age_{ti}-27)+\pi_{2i}(age_{ti}-27)^2+e_{ti}$$
$$\pi_{0i}=\beta_{00}+\beta_{01}(CNDW21)_i+\beta_{02}(CONDITION)_i+r_{0i}$$
$$\pi_{1i}=\beta_{10}+\beta_{11}(CNDW21)_i+\beta_{12}(CONDITION)_i+r_{1i}$$
$$\pi_{2i}=\beta_{20}+\beta_{21}(CNDW21)_i+\beta_{22}(CONDITION)_i+r_{2i} \quad (2)$$

With *CONDITION* in the model, *CNDW21* was a significant predictor of intercept, b_{01} = 0.10, p = .046, and approached significance for linear slope at 27 months, b_{11} = 0.02, p = .07. When controlling for *CNDW21,* there was no significant difference between the treatment and control groups on the intercept, b_{02} = -0.63, p = .63, or on the linear slope at 27 months, b_{12} = 0.41, p = .27. However, even when controlling for *CNDW21, CONDITION* approached significance as a predictor of acceleration from 21 to 30 months, b_{22} = 0.11, p = .08, accounting for 9.2% of the variance in quadratic trends (see Model 2b, Table 4). Although the group difference in acceleration was not statistically significant, average acceleration was more than three times larger for children in the treatment group compared to the control group, $\hat{\pi}_2$(*treatment*) = .17, $\hat{\pi}_2$ (*control*) = .05, respectively (see Figure 1a). Significant variability remained among children in Model 2b, with significant between-child variation, for intercept VAR(r_0) =12.94, p < .001, linear growth VAR(r_1) =0.98, p < .001 and quadratic growth VAR(r_2) = 0.02, p < .001, respectively.

Interactions between *CONDITION* and *CNDW21* were also constructed by multiplying the deviation of *CNDW21* from the grand mean with *CONDITION* and entered as a predictor in the model. The two-way interaction was not significant, *p = .91,* nor were the three-way interactions with linear, p = .33 and quadratic growth, p = .30, indicating that there was not any moderation of the treatment effect with *CNDW21.*

Parent Input Effects on Children's Growth in Sentence Diversity

Given the substantial variability in toy talk with lexical NP subject types for parents in the treatment group following instruction, follow-up analyses were conducted at the level of individual parent-toddler dyads. Recall lexical NP subject types at 24 months (NP type24) ranged from 5 to 40 for the treatment parents and from 1 to 13 for the control parents. Figure 1b displays the variability in children's estimated level-1 growth trajectories for sentence diversity with third person subjects. Given that *CNDW21* was a significant predictor of growth in sentence diversity, children's *CNDW* from 21 to 30 months was group-mean centered and included as a time-varying covariate (see Equation 3 & Model 3a, Table 4) to control for developmental differences in children's readiness for sentence production and the potential influence of children's lexical diversity on parents' use of lexical NPs. To test the hypothesis that lexical NP subject types in parent input was a significant predictor of level-1 variance in children's sentence diversity, parent lexical NP subject types was grand-mean centered and added as a level-2 predictor (see Equation 3 & Model 3b, Table 4).

$$Sentence\ Diversity_{ti}=\pi_{0i}+\pi_{1i}(age_{ti}-27)+\pi_{2i}(age_{ti}-27)^2+\pi_{3i}(CNDW)_{ti}+e_{ti}$$
$$\pi_{0i}=\beta_{00}+\beta_{01}(NP\_\ type24)_i+r_{0i}$$
$$\pi_{1i}=\beta_{10}+\beta_{11}(NP\_\ type24)_i+r_{1i}$$
$$\pi_{2i}=\beta_{20}+\beta_{21}(NP\_\ type24)_i+r_{2i}$$
$$\pi_{3i}=\beta_{30}+\beta_{31}(NP\_\ type24)_i+r_{3i} \quad (3)$$

Children's number of different words was a statistically significant predictor of sentence diversity trajectories over time, $b_{30} = 0.08$, $p < .001$, 95% CI [0.05, 0.11]. The addition of *CNDW* in Model 3a accounted for an additional 36.9% of the variance of children's sentence diversity and remained a significant predictor of sentence diversity after adding the parent input predictor variable (see Models 3a & 3b, Table 4). Parents' lexical NP subject types was a significant predictor of both linear growth in sentence diversity at 27 months, $b_{11} = 0.05$, $p = .024$, 95% CI [0.006, 0.08] and quadratic growth, $b_{21} = 0.006$, $p = .048$, 95% CI [0.00006, 0.01], accounting for 19.8% and 8.16% of the between-child variance in estimates of the linear and quadratic growth, respectively.

Parents' lexical NP subject types was not a significant predictor of average sentence diversity at 27 months, nor of *CNDW* over time, *p's* > .05 (see Model 3b, Table 4). The fixed effects for intercept, linear growth, and quadratic growth remained statistically significant even after controlling for all individual predictors, $\beta_{00} = 4.78$, $p = .001$, $\beta_{10} = 0.97$, $p = .001$, $\beta_{20} = 0.13$, $p = .001$ (see Model 3b, Table 4). Likewise, there was significant random variation remaining in the growth parameters after accounting for all predictors, with significant between-child variation, for intercept VAR(r_0) = 12.35, p < .001, linear growth VAR(r_1) = 0.83, $p < .001$, and quadratic growth VAR($r2$) = 0.02, $p < .001$, respectively.

Discussion

The current study tested a theoretically-motivated hypothesis regarding the effect of increasing subject diversity in parent language input on children's early grammatical growth. The findings demonstrate the feasibility of using toy talk strategies to alter this specific property of parent language input and the contribution of this input modification to children's ability to combine subjects and verbs in more flexible ways over time. The use of an intervention design provides new evidence for interpreting this link causally. Although the empirical findings are promising, they must be interpreted cautiously in light of the quasi-control research design. The significance of the findings is addressed first, followed by a discussion of the theoretical and translational implications.

Toy Talk Instruction Alters Subject Diversity in Parent Input

The first research question examined the efficacy of toy talk instruction with parents. Following instruction, parents in the treatment group produced more frequent lexical NP subjects with canonical subject-verb-(object) word order and more diverse lexical NP types than parents in the control group. The effect sizes for lexical NP subject tokens and types were both large. These findings indicate that this grammatical property of language input can be altered with relatively brief instruction, at least for a self-selected sample of primarily college educated parents. In contrast, the absence of intervention effects on more general input properties provided evidence for the precise effects of the instruction. Although main effects for Time were observed for MLU, lexical diversity, and declaratives with pronominal subjects, there were no treatment effects on these variables, nor on total utterances or labeling. The absence of treatment effects on other variables is noteworthy. For example, had parents only learned how to *give the item its name*, but not also how to *talk about the toys* (i.e., comment about actions, attributes, locations, etc), treatment effects would have been evident for labeling. Alternatively, if parents had only learned how to *talk about the toys*, and not how to label the items, toy talk with pronominal subjects would have increased without a corresponding change on lexical NP subjects.

The pattern of changes for the parent input variables suggests that age and/or developmental progress in children's language abilities may influence general properties of parent input such as MLU and lexical diversity whereas special instruction is required to increase declarative sentences with lexical NP subjects in parent input. In the absence of instruction, this type of input sentence is rare, accounting for less than 3% of all input utterances. With instruction, lexical NP subjects were increased to 10% of input utterances. Interestingly, the increase in declaratives with lexical NPs subjects was accompanied by a comparable reduction in the frequency of questions. Thus, we conclude that the use of lexical NPs is a malleable property of parent input and that our instructional approach altered the relative proportion of input sentences that conform to basic declarative sentence structure.

Child Lexical Diversity and Input Subject Diversity Promotes Child Sentence Diversity

Coupling the intervention design with multilevel growth modeling, our second question tested the hypothesis that the parent-implemented intervention, in general, and parent input sentences with diverse lexical NP subjects, in particular, would accelerate children's early sentence diversity. Our findings provide partial support for this hypothesis. In the group analyses of treatment effects, children's lexical diversity was the primary predictor of later sentence diversity scores. Children's number of different words at 21 months was a significant predictor of sentence diversity scores at 27 months, and it approached significance for linear growth at 27 months. Treatment condition was not related to these growth components; however, group differences in acceleration from 21 to 30 months approached significance.

In the analyses of parent input effects, growth in children's number of different words from 21 to 30 months was again a significant predictor, accounting for 37% of the variance in sentence diversity growth during this same time period. The significant relationship between growth in lexical diversity and sentence diversity is consistent with prior findings of longitudinal stability in early language development (Bates, Bretherton, & Snyder, 1998; Hsu, Hadley, & Rispoli, 2015; Marchman & Thal, 2005) and it is not surprising, given the way our measure of sentence diversity was computed. Children's ability to produce a number of different words in conversational speech was necessary to demonstrate lexical flexibility with basic clausal structure. In addition, parent use of lexical NP subject types was also a significant predictor of children's growth in sentence diversity, after controlling for children's lexical diversity. Parent lexical NP subjects did not influence the number of different subject-verb combinations children produced at 27 months of age, but they did enhance children's *rate of growth* in sentence diversity. Parents' lexical NP subject types accounted for additional variance in children's linear and quadratic growth in sentence diversity, approximately 20% and 8%, respectively. These findings indicate that typical variation in input subject diversity, in combination with the variation introduced through toy talk instruction, contribute to children's early grammatical growth. Future studies are needed to better understand this natural variation as well as ways to improve parent implementation of toy talk instruction in order to promote child outcomes.

The significance of the group and individual findings depends upon one's perspective. If emphasis is placed on short-term outcomes, the lack of significant treatment and input effects on children's sentence diversity by 27 months may be of concern. However, if the low intensity and brief duration of the instruction (i.e., 3 sessions distributed over 6 to 8 weeks) are considered, the findings seem promising. Alternatively, if the contribution of input to children's growth trajectories is emphasized, the findings are more compelling. Small differences in input quality may confer developmental advantages that accumulate over time. We prefer the latter perspective, assuming that an early advantage in rate of sentence diversity growth will translate into greater use of diverse sentences at a later point in development. Future research is needed to demonstrate whether small shifts in children's growth trajectories translate into meaningful differences in later language abilities.

Theoretical and Translational Implications

The identification of parent input subject diversity as a catalyst for children's sentence diversity reveals important new information about how children make use of input in the acquisition of grammar. To achieve lexically flexible clause structure, children must recognize that *any* noun phrase can be the subject of a sentence. However, input poses an obstacle to the child learner. There is a strong tendency for the subject position to be reduced to a small set of pronouns in interpersonal conversations (Schleppegrell, 2001). We hypothesized that increased subject diversity in input sentences would help children identify the subject NP as a separate constituent from the VP, strengthening the representation of the subject position in the mental grammar. With stronger grammatical representations, we expected children would have greater flexibility with basic clause structure as reflected in more different combinations of subjects and verbs in their sentences. We focused on sentences with third person subjects because third person pronouns can be replaced by lexical NPs. We reasoned that parent input with more low-frequency lexical NP subjects would have lower transitional probabilities at the subject-predicate boundary compared to input samples with primarily high-frequency, pronominal subjects (e.g., *it, that, you*; Thompson & Newport, 2007). However, we did not measure the transitional probability cues in the input sample directly, and therefore we cannot claim that this cue was the primary or only driver of the language growth observed. Instruction on toy talk strategies in combination with the responsive interaction strategies may have also increased cross-sentential cues to constituent structure (Hoff, 1985; Morgan et al., 1989). For example, we coached parents during the individual video feedback sessions on how to expand children's single words and word combinations with toy talk sentences. We also told parents not to worry when they used pronominal subjects naturally, and then encouraged them to name the object in the next opportunity as illustrated in the discourse below.

C hot.

M {oh} it[TT:P] is hot.

C up there.

M the egg[TT:NP] is on top.

In addition, we pointed out how parents could use lexical NPs from their prior utterances (e.g., *You're rocking the baby*.) as the basis for a follow-up toy talk sentence (e.g., *The baby is sleeping*.). The added benefits of subject constituent expansion, subject constituent contrast (e.g., it/the egg), and the moving of lexical NPs between object and subject position within a short stretch of discourse should be examined in future studies.

Of course, it is possible that parents who spent more time talking about third person subjects simply provided their children with more opportunities use these sentence types. We cannot rule out this possibility. However, the number of parent sentences with lexical NP subjects was only a small percentage of parent utterances (i.e., 10%). Moreover, the link between parents' subject diversity and children's sentence diversity was not based on a single sample of parent-child interaction. Rather, the parent input variable was based on parent sentences obtained when children were 24-months of age, and growth trajectories for children's sentence diversity were estimated over a nine month period, from 21 to 30 months of age.

The impact of subject diversity in parent input sentences has the potential to extend beyond the direct effects observed for children's sentence diversity. For example, input sentences with third person lexical NP subjects may better align acoustic cues with the constituent boundary between the subject NP and VP. Parents may also be more likely to produce uncontracted copula and auxiliary forms with longer, low-frequency lexical NP subjects than with high-frequency pronominal subjects (Frank & Jaeger, 2008). These difference in input sentences may support children's acquisition of tense and agreement morphemes. A follow-up analysis showed that parents who received toy talk instruction did indeed produce significantly more uncontracted instances of copula *is* (e.g., *The pig is dirty. Your tower is tall.*) than did parents in the control group ($M = 10.58$ vs $M = 4.53$, $t = 2.92$, $p = .007$). This difference is important to consider because declarative sentences with full copula *is* forms have been shown to promote children's acquisition of copula *is* (Rispoli, Papastratakos, Stern, & Hadley, 2015) and earlier learning of copula *is* facilitates children's productivity of verb-*s* through cross-morpheme facilitation (Rispoli et al., 2012; Rispoli & Hadley, 2014; Rispoli, 2015). Analyses are currently underway to document the impact of toy talk instruction on children's marking of tense and agreement.

Increased use of toy talk sentences in conversational interactions may also support children's acquisition of "academic language," the more literate language register used in school contexts, characterized by more specific low-frequency words, declarative statements, and expanded lexical NP subjects (Schleppegrell, 2001). Children's acquisition of literate language features are needed for successful decontextualized language use (Curenton & Justice, 2004; Eisenberg et al., 2008; Greenhalgh & Strong, 2001). To acquire this register and support successful school transitions, children are likely to benefit from exposure to descriptive talk in the toddler and preschool years. van Kleeck (2014a, 2014b) notes that the features of the literate language register are more prevalent in the parent-child interactions of mothers with higher levels of education during shared book reading activities and that these features are interwoven into everyday conversations in these homes. Unfortunately, we cannot address differences in the quantity and quality of descriptive talk in the home language environment, nor how common toy talk sentences may be during shared book reading. Rather, the toy talk strategies examined in this study are offered as a means of increasing descriptive talk during play and other routine family activities. Increasing exposure throughout the day is especially important for toddlers from socioeconomically disadvantaged homes who are typically exposed to less descriptive talk in their linguistic environments than children from more advantaged homes (Hart & Risley, 1995; Risley & Hart, 2006).

Limitations and Future Directions

The current study was designed to evaluate the feasibility of altering a specific grammatical property of parent input sentences with a relatively simple parent education program and to explore the early efficacy of this instruction on toddler's grammatical growth. Although our initial findings are encouraging, two major limitations should be noted. First, the quasi-control group introduced the potential for participant selection bias. Second, input effects were only observed in the individual analyses on dynamic measures of growth over time, not on scores at the 27-month intercept, or for the treatment group as a whole.

A propensity score analysis (Rosenbaum & Rubin, 1983) was considered as a means of addressing this potential for participant selection bias, but the small sample sizes in this study were inadequate for employing this analytic approach (Freedman & Berk, 2008). Therefore, we controlled for the most salient variables through matching on CDI total words at 21 months of age and statistical control of key variables in the HLM analyses. Regression analyses have been demonstrated to reduce bias as well as, or better than, propensity score analyses, particularly when the covariates are theoretically-based (Shadish, Clark, & Steiner, 2008). Further, careful selection of covariates is more important in reducing bias than the analytic method (Steiner, Cook, Shadish, & Clark, 2010).

The unbalanced composition of parent educational levels and racial/ethnic diversity between groups also limits the generalizability of the findings. Although parents in the treatment group learned the strategies with brief instruction, all had at least some college education and the majority had advanced degrees. To demonstrate the real translational impact of the toy talk strategies, the amount of instruction and feedback needed for parents from a range of educational levels must be explored. In addition, future research should examine culturally sensitive ways of incorporating descriptive talk into the communication and child-rearing practices of individual families (van Kleeck, 1994, 2014a).

Post-hoc analyses also revealed our groups were not well matched on family history of speech, language, and/or learning disabilities (Rice, Haney, Wexler, 1998). Parents reported a positive family history for more children in the control group ($n = 8$) than in the treatment group ($n = 1$). In the control group, three children had one sibling with a positive history, three had fathers with a positive history, and two had multiple family members with a positive history. In the treatment group, only one child had a sibling with a positive history. A positive family history of a speech, language, and/or learning disability provides an indirect measure of biological vulnerability for language learning and offers another possible explanation for the limited acceleration apparent in the control group. For example, Hadley and Holt (2006) reported flatter growth trajectories for productive use of tense and agreement marking for toddlers with a positive family history compared to children without a positive family history. However, positive family history is rarely considered when characterizing the response to intervention of individual children. Direct measures of parent language abilities should be included in future studies to estimate heritable aspects of aptitude for language learning.

Several other factors may have contributed to the lack evidence for group treatment effects and input effects on the sentence diversity intercept at 27 months of age. One possibility is that differences in children's developmental readiness for the transition to sentence production reduced the impact of the treatment effects observed for the group as a whole as well as the input effect on children's 27-month sentence diversity scores. We recruited children at 21 months of age so that instruction could take place prior to the children's use of third person sentences, but some children were producing only single words at this age. For these children, the intervention may not have been as beneficial because it was initiated too early. In addition, we may have underestimated the length of time needed to bring about child change. Although diverse third person sentences are expected for nearly all typically developing children by 30 months of age (McKenna & Hadley, 2014), we centered the growth models earlier, at 27 months, with the expectation that intervention would facilitate the use of diverse third person sentences at an earlier age. This may have been overly ambitious, especially for children who were single word users at 21 months of age. Future translational research is needed to explore these possibilities, initiating the intervention when child show developmental readiness for producing word combinations rather than at one uniform age and gathering outcome data over a longer period of time. Another possibility is that we underestimated the dosage – or the rate of exposure to lexical NP subjects – required to bring about change in children's grammatical development (Warren, Fey, & Yoder, 2007). In this initial study, we did not want to modify parent discourse to the point it seemed unnatural or aversive (Proctor-Williams, 2009). Therefore, we instructed parents to use toy talk sentences about once or twice per minute. Treatment parents did just that, producing an average of 1.34 toy talk sentences per minute. This was true of parents who participated both before and after the instructional modifications made midway through the study. Future instruction could encourage parents to use lexical NPs more frequently without sacrificing naturalness.

Conclusions

Studies of input effects can inform us about the mechanisms of grammatical acquisition. Input studies have evolved from broad explorations to hypothesis-driven tests with theoretically-motivated variables. This study focused on a single grammatical property, subject diversity in parent input sentences, and its link to children's lexical flexibility with basic clause structure. The parent-implemented intervention component increased the probability that input effects would be observed and causal linkages could be proposed. Intervention designs are particularly valuable in advancing understanding of language learning mechanisms, while simultaneously providing an empirical basis for clinical and educational practices. This study has contributed to both important goals.

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Appendix Examples of Toy Talk Coding and Labeling in Parent Input

The following excerpts of successive utterances from two treatment parents are provided to illustrate the coding of toy talk with lexical noun phrase subjects (TT:NP), toy talk with pronominal subjects (TT:P), and labeling. Both parents produced an average number of TT:NPs following instruction (M = 38, F = 36, Treatment *M* = 40.05, *SD* = 22.26). Explanations are provided for each parent sentence that did not receive a code. Parent utterances without explicit subjects and predicates are indicated by dashes (--). The slash (/) indicates a bound or contracted morpheme. Words in parentheses ( ) indicate utterance revisions and words in curly brackets { } are interjections; content within both conventions are excluded from the computation of parent mean length of utterance.

Parent Utterance	Explanation for no code
M is there a mirror?	Structural question
M no mirror on this penguin.	--
M but a mirror on this.	--
M the penguin[TT:NP] is up there.	
M let's sit down together and eat our egg.	(understood) 2nd person subject
M i/'ll sit in the blue chair.	1st person subject
M blue?	--
M the blue chair?	--
M should i sit here or here?	Structural question
M blue?	--
M sit in the blue chair?	--
M green.	--
M this plate[TT:NP] is green.	
M {oh} it[TT:P] is hot.	
M the egg[TT:NP] is on top.	
M the egg[TT:NP] is in the cup.	
M {oh} do you wanna get the baby out of the closet?	Structural question
M in the closet.	--
M get the stroller out.	(understood) 2nd person subject
M there[Lab]/'s orange juice in the bottle.	
M we/'ll just pretend.	1st person plural subject
M there[Lab]/'s milk in this bottle.	
F is this old bessie the cow?	Structural question
F it[Lab]/'s a cart for the pumpkin/s.	
F put the pig/s in there.	(understood) 2nd person subject
F carry the pig/s around.	(understood) 2nd person subject
F farmer[TT:NP]/'s in the tractor.	
F yeah.	--
F the horsie.	--
F the horsie[TT:NP]/'s walk/ing.	

Parent Utterance	Explanation for no code
F the horsie/z tail.	--
F the fence[TT:NP] broke.	
F let's fix the fence.	(understood) 2nd person subject
F it[TT:P]/'s fixed.	
F you wanna play with the barn?	Structural question
F the big cow[TT:NP] fell.	
F yeah.	--
F baby cow.	--
F bessie.	--
F that[Lab]/'s the daddy?	
F (this is) bessie[TT:NP]/'s the mama cow?	
F yeah.	--
F a chicken.	--
F put/ing the chicken away.	--
F i don't know where the baby/s are.	wh-movement in 3rd person embedded clause

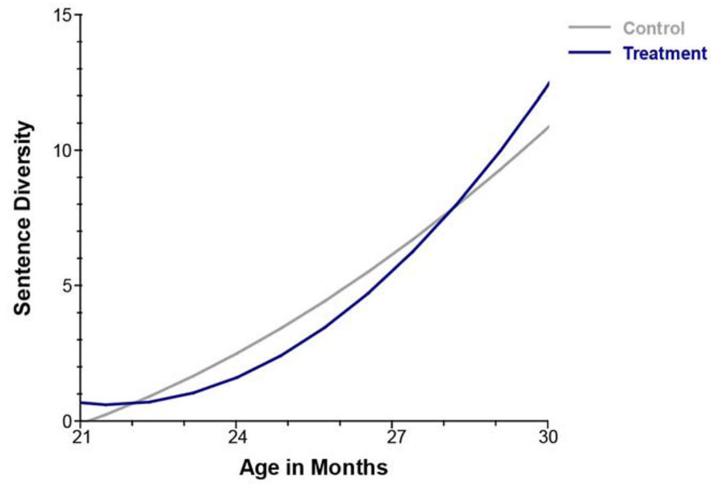

Figure 1a

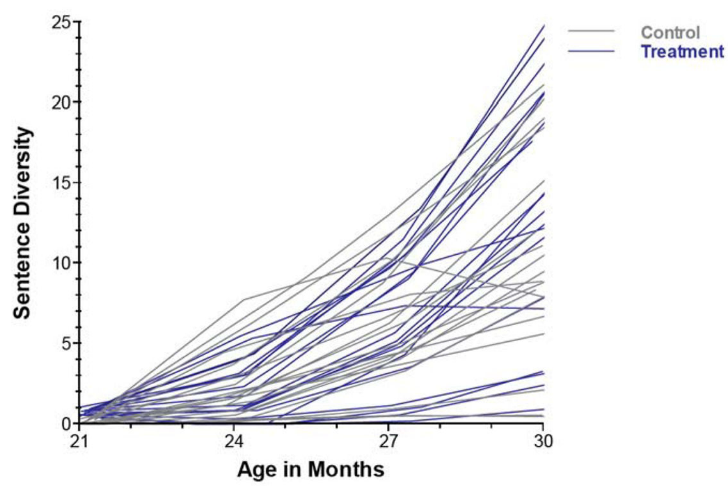

Figure 1b

Figure 1.

Figure 1a. Group differences in growth trajectories for sentence diversity from 21 to 30 months

Figure 1b. Individual growth trajectories for sentence diversity from 21 to 30 months

Table 1

Means and (Standard Deviations) for Parent Input Measures by Time and Condition

Measure	Pre-Instruction				Post-Instruction			
	Control		Treatment		Control		Treatment	
	M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
Parent Total Utterances	377.89	107.57	398.68	102.96	386.58	98.96	384.68	92.21
Parent Mean Length of Utterance	3.76	0.52	3.78	0.48	3.96	0.52	4.02	0.54
Parent Number of Different Words	232.37	56.14	236.79	47.99	254.32	49.25	266.63	51.60
Labeling	18.63	9.80	18.16	9.74	21.68	9.84	19.16	9.79
Toy Talk: Pronominal subjects	14.79	8.67	15.42	7.71	19.58	13.67	22.32	12.68
Toy Talk: Lexical NP subjects	7.32	5.09	9.63	6.07	10.05	7.25	40.05	22.26
Toy Talk: Lexical NP types	4.68	3.04	5.58	2.83	6.00	2.96	18.05	9.99

Note. Pre-Instruction data at 21-month session. Post-Instruction data at 24-month session. Control $n = 19$; Treatment $n = 19$. NP = Noun Phrase

Table 2

Repeated Measure ANOVA Results for Parent Input Measures

	Measure	$F(1,36)$	p	$\eta^2 p$
Condition (Between)	Parent Total Utterances	.109	.743	.003
	Parent MLU	.066	.798	.002
	Parent NDW	.302	.586	.008
	Labeling	.331	.569	.009
	Toy Talk: Pronoun	.340	.564	.009
	Toy Talk: NP	**27.279**	**<.001**	**.431**
	Toy Talk: NP Types	**18.587**	**<.001**	**.340**
Time (Within)	Parent Total Utterances	.029	.867	.001
	Parent MLU	**9.728**	**.004**	**.213**
	Parent NDW	**14.837**	**<.001**	**.292**
	Labeling	1.243	.272	.033
	Toy Talk: Pronoun	**7.872**	**.008**	**.179**
	Toy Talk: NP	**42.247**	**<.001**	**.540**
	Toy Talk: NP Types	**44.947**	**<.001**	**.555**
Time * Condition	Parent Total Utterances	.519	.476	.014
	Parent MLU	.080	.779	.002
	Parent NDW	.345	.561	.009
	Labeling	.319	.576	.009
	Toy Talk: Pronoun	.256	.616	.007
	Toy Talk: NP	**29.450**	**<.001**	**.450**
	Toy Talk: NP Types	**29.429**	**<.001**	**.450**

Note. MLU = mean length of utterances; NDW = number of different words; NP= Noun Phrase; $N = 38$

Table 3

Descriptive Statistics for Child Measures by Condition by Measurement Point

	Control		Treatment		
	M	*SD*	*M*	*SD*	*t*
C&I Utterances					
21 Months	101.63	73.90	143.26	108.38	−1.38
24 Month	170.05	86.19	237.63	164.29	
27 Months	225.95	116.24	258.63	139.63	
30 Months	265.32	85.83	254.95	101.99	
MLU					
21 Months	1.20	0.22	1.23	0.22	−0.37
24 Months	1.55	0.46	1.52	0.48	
27 Months	1.93	0.48	1.95	0.47	
30 Months	2.26	0.48	2.34	0.66	
CNDW					
21 Months	18.53	12.38	26.11	14.02	−1.77
24 Months	47.11	25.91	52.26	18.95	
27 Months	75.11	31.64	79.37	25.03	
30 Months	91.79	25.36	102.00	36.35	
Verb diversity (in 1st person sentences)					
21 Months	0.84	1.86	1.05	1.68	−0.37
24 Months	3.89	3.68	3.32	4.10	
27 Months	7.89	5.13	6.37	5.22	
30 Months	9.53	4.23	10.05	4.84	
Sentence diversity (in 3rd person sentences)					
21 Months	0.16	0.69	0.37	0.68	−0.95
24 Months	2.11	3.13	2.68	2.67	
27 Months	6.42	5.22	5.68	4.67	
30 Months	10.47	6.82	13.95	8.70	

Note. C&I Utterances = Total number of spontaneous, complete, and intelligible utterances; MLU = mean length of utterances in morphemes; CNDW = child number of different words; Control n =19; Treatment n = 19. No *t*-test comparisons were significantly different at $p < .05$.

Table 4

Children's Sentence Diversity Growth with Treatment Condition and Parent Lexical NP Types

	Unconditional Growth Models		Conditional Group Effects		Conditional Individual Effects	
	Model 1a	Model 1b	Model 2a Vocabulary	Model 2b Condition	Model 3a Vocabulary	Model 3b NP types
Fixed Effects						
Intercept, β_{00}	6.89^{***}	5.81^{***}	5.82^{***}	6.12^{***}	4.80^{***}	4.78^{***}
CNDW21			0.10†	0.10^{*}		
Condition				−0.63		
Toy Talk:NP types						0.07
Linear growth, β_{10}	1.30^{***}	1.59^{***}	1.59^{***}	1.39^{***}	0.98^{***}	0.97^{***}
CNDW21	.		0.03^{*}	0.02†		
Condition				0.41		
Toy Talk:NP types						0.05^{*}
Quadratic growth, β_{20}		0.11^{***}	0.11^{***}	0.06	0.13^{***}	0.13^{***}
CNDW21			0.003	0.002		
Condition				0.11†		
Toy Talk:NP types						0.006^{*}
CNDW					0.08^{***}	0.08^{***}
Toy Talk:NP types						−0.001
Random Effects						
Intercept, VAR(r_0)	15.71^{***}	14.63^{***}	12.97^{***}	12.94^{***}	12.62^{***}	12.35^{***}
Linear growth, VAR(r_1)	0.54^{***}	1.16^{***}	1.02^{***}	0.98^{***}	1.03^{***}	0.83^{***}
Quadratic growth, VAR(r_2)		0.02^{***}	0.02^{***}	0.02^{***}	0.02^{***}	0.02^{***}
CNDW					0.002^{***}	0.002^{***}
Level-1, VAR(e)	8.72	3.96	3.93	3.87	2.50	2.43

Note. CNDW = child number of different words; CNDW21 = child number of different words at 21 months; NP = Noun Phrase; Models age-centered at 27 months.

$^{***}p < .001$.

$^{*}p < .05$,

† $p < .10$