Research Article

Input Subject Diversity Accelerates the Growth of Tense and Agreement: Indirect Benefits From a Parent-Implemented Intervention

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Purpose: This follow-up study examined whether a parent intervention that increased the diversity of lexical noun phrase subjects in parent input and accelerated children's sentence diversity (Hadley et al., 2017) had indirect benefits on tense/agreement (T/A) morphemes in parent input and children's spontaneous speech.

Method: Differences in input variables related to T/A marking were compared for parents who received toy talk instruction and a quasi-control group: input informativeness and full *is* declaratives. Language growth on tense agreement productivity (TAP) was modeled for 38 children from language samples obtained at 21, 24, 27, and 30 months. Parent input properties following instruction and children's growth

in lexical diversity and sentence diversity were examined as predictors of TAP growth.

Results: Instruction increased parent use of full *is* declaratives ($\eta_p^2 \geq .25$) but not input informativeness. Children's sentence diversity was also a significant time-varying predictor of TAP growth. Two input variables, lexical noun phrase subject diversity and full *is* declaratives, were also significant predictors, even after controlling for children's sentence diversity.

Conclusions: These findings establish a link between children's sentence diversity and the development of T/A morphemes and provide evidence about characteristics of input that facilitate growth in this grammatical system.

How do children use language input to acquire the grammar of their native language? Research traditions in psychology and linguistics have tackled this fundamental question by focusing on different aspects of the problem space (Chomsky, 1995; Ingram, 1989; Lidz & Gagliardi, 2015; Tomasello, 2003; Valian, 1999; Yang, 2004). Psychologists have contributed descriptions of the language input directed to children, insights about the social and cognitive underpinnings of learning, and evidence of domain-general, statistical learning mechanisms that children use to detect patterns in language input. Generative linguists have characterized children's grammatical representations, allowing hypotheses to be tested about the way abstract grammatical structures are related to one another in mental grammar and in development. Unfortunately, research

programs about natural learning environments (e.g., Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002; Huttenlocher, Vasilyeva, Waterfall, Vevea, & Hedges, 2007; Rowe, 2012; Vasilyeva, Waterfall, & Huttenlocher, 2008), learning mechanisms (e.g., Gómez, 2002; Thompson & Newport, 2007), and the nature of grammatical representations (e.g., Yang, 2002; Lidz & Gagliardi, 2015) often proceed in isolation. However, these enterprises need not remain independent. Moreover, the integration of insights from different disciplinary traditions is crucial for developing evidence-based grammatical interventions for young children.

By manipulating properties of language input, language interventions can be used to test hypotheses about learning mechanisms while addressing the practical need for effective and more efficient language interventions. For children with specific language impairment (SLI), efforts to evaluate the efficacy of grammatical interventions are particularly important, given the pronounced difficulty they have with the acquisition of grammar (Leonard, 2014; Oetting & Hadley, 2017). In light of this need, many clinical investigators have evaluated the efficacy of interventions for tense/agreement (T/A) morphemes (Fey, Cleave, & Long, 1997; Fey, Cleave, Long, & Hughes, 1993; Fey &

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Finestack, 2009; Leonard, Camarata, Brown, & Camarata, 2004; Leonard, Camarata, Pawłowska, Brown, & Camarata, 2006; 2008; Proctor-Williams, 2009; Tyler, Lewis, Haskill, & Tolbert, 2002, 2003). More recently, investigators have moved beyond comparisons of treatment agents, procedures, dosage, and goal attack strategies to explore how differences in input properties promote learning (Leonard, Fey, Deevy, & Bredin-Oja, 2015; Plante et al., 2014) and how differences in children's grammatical knowledge allow them to make better use of the therapeutic input provided (Leonard et al., 2004, 2006; Pawłowska, Leonard, Camarata, Brown, & Camarata, 2008).

For example, Plante et al. (2014) manipulated statistical properties of input known to promote learning in artificial miniature learning studies in a grammatical intervention for preschoolers with SLI. The input manipulation was combined with conversational recasting, an empirically supported technique (Cleave, Becker, Curran, Van Horne, & Fey, 2015). Recasts are adult responses to a child's prior platform utterance (e.g., *pizza cooking*) that maintain the semantic content of the child's utterance while modeling the treatment target in a well-formed adult version of the utterance (e.g., *The pizza is cooking*). Recasts are inherently responsive turns, building upon the child's attentional focus and intention to communicate. Children received 30-min individual intervention sessions daily for approximately 5 weeks. Treatment targets (e.g., auxiliary *is*, past *-ed*) were individualized. Clinicians structured the play activities and discourse to increase children's attempts at treatment targets and responded to these attempts with recasts. Children were exposed to 24 recasts per session; however, the number of verbs co-occurring with treatment targets varied by condition. Children in the low-variability condition heard 12 different verbs recast twice, whereas children in the high-variability condition heard 24 different verbs recast only once. Plante et al. (2014) observed significantly greater treatment effects for children in the high-variability condition. They concluded that high verb variability within a single session shifted children's attention toward their treatment targets—the more stable and frequent structures in the input (Gómez, 2002).

In another study, Pawłowska et al. (2008) explored the relationship between pretreatment grammatical knowledge and the ability of preschoolers with SLI to learn agreement morphemes from focused input (Leonard et al., 2006). In this focused stimulation intervention, children received concentrated exposure to either third person singular *-s* or auxiliary *is/are/was* in each session, specifically 12 models in scripted stories and 12 conversational recasts in play. Children participated in two sessions per day, two times per week over 6 months for a total of 96 sessions. The authors hypothesized that children's developmental readiness to acquire agreement morphemes would depend upon their pretreatment ability to mark number with plural *-s* and produce subject-verb constructions, two basic skills underlying the production of sentence subjects marked for number. In evaluating children's treatment progress, Pawłowska et al. (2008) found that posttreatment accuracy

on the target morpheme was predicted by a combination of age, pretreatment accuracy with plural *-s*, and the percentage of utterances with lexical verbs co-occurring with a subject. In contrast, treatment progress was not predicted by mean length of utterance (MLU) or by grammatical structures unrelated to agreement (i.e., progressive *-ing*, nonthematic *of*) that develop in the same age range as plural *-s*. These findings demonstrate that children's grammatical knowledge has an influence on their ability to learn from focused input.

In a third study, Hadley et al. (2017) used a parent-implemented intervention to manipulate the diversity of sentence subjects in parent input to toddlers with typical development to facilitate sentence development, specifically unique subject-verb combinations. Hadley et al. (2017) hypothesized that lexical noun phrase (NP) subjects in parent input would alter cues that signal the boundary between subject and predicate constituents, and this would, in turn, strengthen children's representation of clause structure. Parents received instruction on responsive interaction and language modeling strategies during a 1.5-hr parent group education session and two 1-hr individualized coaching sessions (see the Method section and Hadley et al., 2017, for more details). Two novel toy talk strategies were used to alter parents' lexical NP subjects in declarative sentences: (a) *Talk about the toys* increased third person sentence subjects referring to concrete objects in the play environment and (b) *give the object its name* increased nouns in subject position. Following toy talk instruction, parents in the treatment group increased their frequency and diversity of lexical NP subjects in toy talk sentences (e.g., *Your castle is wobbling*) compared with parents in a quasi-control group. Although treatment condition (i.e., treatment vs. control) was only a marginal predictor of children's growth in sentence diversity after controlling for growth in children's number of different words (NDW), parent input subject diversity, operationalized as the number of different lexical NP subjects each parent produced, was a significant predictor. The significant input effects revealed at the level of the individual parent-toddler dyads make sense in the context of the parent-implemented intervention. That is, parents varied in how well they learned and delivered the intervention's active ingredient (i.e., the number of different lexical NP subjects in toy talk sentences).

Hadley et al. (2017) proposed that multiple cues to clause structure were altered by parents' lexical NP subjects in declarative sentences. First, input samples with more low-frequency lexical NP subjects would have lower transitional probabilities or less predictability between the subject and the following verb (e.g., *The oven* → *is hot*) than input samples with primarily high-frequency pronominal subjects (e.g., *This* → *is hot*). Lower transitional probabilities between the nouns in the subject NPs and the verbs that follow should make the subject-predicate constituent boundary more prominent to the learner (Thompson & Newport, 2007). Second, declarative input sentences with lexical NP subjects might better align prosodic cues, such

as syllable lengthening, pausing, and pitch changes with the subject–predicate constituent boundary (Fisher & Tokura, 1996), because declarative sentences with lexical NP subjects are more likely to be followed by uncontracted copula and auxiliary forms (e.g., *The pig is hiding*) than those with pronominal subjects (e.g., *He's hiding*; Frank & Jaeger, 2008). In addition, lexical NP subjects could increase cross-sentential cues to constituent structure, specifically moved phrases and pronominalization (Hoff-Ginsberg, 1985; Morgan, Meier, & Newport, 1989), as parents moved lexical NPs from object position to subject position (e.g., *I can't find the pig; the pig is hiding*) and varied pronouns with lexical NPs in the subject position of their input sentences. In sum, by increasing the frequency and diversity of lexical NP subjects in declarative input sentences, toy talk instruction shifted transitional probabilities, prosodic cues and cross-sentential cues to highlight the subject constituent, which, in turn, helped strengthen the child's representation of basic clause structure. The current study expands the investigation of Hadley et al. (2017) by using the same study participants to determine whether toy talk instruction also changed properties of T/A morphemes in parent input without any specific instruction on these morphemes and whether these properties of parent input, in concert with children's growth in sentence diversity, promoted growth in T/A morphemes.

Toy talk instruction was expected to alter parent input for T/A morphemes in two ways, leading to additional benefits for children's T/A growth. First, we predicted increases in parents' input informativeness (i.e., the percentage of verb forms providing unambiguous evidence for tense marking; Hadley, Rispoli, Fitzgerald, & Bahnsen, 2011; Legate & Yang, 2007). Legate and Yang (2007) revealed cross-linguistic differences in the percentage of verb forms unambiguously marked for tense. They found 80.1% and 69.8% of verb forms were unambiguous in child-directed Spanish and French, compared with only 52.9% in English. These percentages, importantly, aligned with empirical differences in the age of acquisition of tense across these languages. Applying this measure to individual parents, Hadley et al. (2011) documented variation among 15 English-speaking parents, with the percentage of overtly marked verb forms ranging from 33.1% to 69.8% ($M = 50.6\%$). Parents' input informativeness was also a significant predictor of toddlers' tense/agreement productivity (TAP) scores at 30 months, accounting for 23.0% of the variance between children. Given these findings, it was expected that toy talk instruction would increase parents' use of declarative statements about objects in the play environment (i.e., third person subjects) and therefore the third person singular cell of the English verb paradigm. Third person is most consistently and distinctively marked for agreement, so an increase in sentences with third person subjects was expected to increase input informativeness (Fitzgerald, Hadley, & Rispoli, 2013; Hadley & Walsh, 2014; Rispoli & Hadley, 2011; Rispoli, Hadley, & Holt, 2012). More informative input, in turn, was predicted to facilitate children's acquisition of the T/A system.

As treatment parents produced more lexical NP subjects in Hadley et al. (2017), we predicted they would use more full *is* declaratives as well, because full *is* forms in declaratives are associated with lower frequency NP subjects, whereas contracted *'s* forms are associated with higher frequency pronominal subjects (Frank & Jaeger, 2008). We hypothesized that parents' full *is* declaratives would facilitate the child's entry into the T/A system for several reasons. First, the derivational simplicity of declarative sentences may support a child's ability to parse the syntactic structure of input sentences (Rispoli, Papastratakos, Stern, & Hadley, 2015). Second, we hypothesized that high input subject diversity with *is* in declarative sentences would facilitate its analysis, whereas low input subject diversity would encourage rote learning of copula and auxiliary *is* and hinder morphemic analysis (Rispoli & Hadley, 2014). Four pronoun-*'s* combinations found in declarative contexts (i.e., *that's*, *it's*, *he's*, *there's*) are listed among the 100 most frequently produced words in parent input (Li & Shirai, 2000; MacWhinney, 2000). Note that this kind of rote learning is dependent on high transitional probabilities between the pronominal subject and the verb that follows. Third, the phonetic substance of syllabic *is* may facilitate its identification as a distinct word (Pinker, 1984). Thus, both lexical NP subjects and the associated tendency to use full *is* forms with these subjects in declarative input sentences could promote children's analysis of *is*. In turn, the identification of copula and auxiliary *is* in the input was predicted to facilitate children's acquisition of the T/A system through cross-morpheme facilitation (Leonard et al., 2004, 2006; Rispoli, 2016; Rispoli et al., 2012; Rispoli & Hadley, 2011, 2014). In cross-morpheme facilitation, the learning of one morpheme facilitates the learning of other morphemes that share grammatical features. The effects of cross-morpheme facilitation have been demonstrated from copula *is* to verb *-s* (i.e., third person singular present tense) for young children with typical development (Rispoli, 2016) and from verb *-s* to auxiliary *is/are/was* and from auxiliary *is/are/was* to verb *-s* for preschool children with SLI (Leonard et al., 2004, 2006).

Also, we expected children with stronger clausal representations to have an advantage analyzing the surface forms that encode T/A features in the input over children with weaker clausal representations. To detect and interpret T/A morphemes in the input, knowledge of clause structure is crucial because T/A features are properties of clauses, not words. As previously noted (Hadley et al., 2011), tense in English has scope over the clause, and agreement is the result of checking features of the subject with features of the verb phrase (Chomsky, 1995). In other words, we predicted children's ability to produce diverse sentences would promote acquisition of the T/A system because children use their developing grammar to parse input sentences and detect new grammatical structures (see Lidz & Gagliardi, 2015, for discussion). To test this hypothesis, we examined whether children's growth in sentence diversity, an indicator of the strengthening of clausal representation (Rispoli et al., 2012; Rispoli & Hadley, 2011), was a significant predictor of growth in T/A marking.

In summary, the purpose of this study was to expand our original investigation to determine whether toy talk, a parent-implemented, language modeling strategy previously shown to accelerate children's sentence diversity, also promoted children's acquisition of the T/A system. Our first research question examined whether toy talk instruction had indirect benefits on parents' use of T/A morphemes, specifically input informativeness and full *is* declaratives. The second research question examined whether developmental changes in children's sentence diversity and parent input properties facilitated growth of T/A morphemes in children's spontaneous speech.

Method

Design

The original study (Hadley et al., 2017) evaluated the efficacy of toy talk instruction on children's growth of sentence diversity by using a quasi-experimental design. Control families were drawn from an earlier longitudinal study of language development (Hadley, Rispoli, Holt, Fitzgerald, & Bahnsen, 2014); therefore, families were not randomly assigned to the treatment and control groups. The use of a quasi-experimental design is considered a cost-effective design element for scaling up language intervention research (Fey & Finestack, 2009). Although collected at different points in time, all treatment and control families were recruited from English-only speaking households in Champaign County, Illinois, and surrounding counties, following the same strategies. Information was distributed to parents through newspapers, community facilities, and listservs. Control families did not receive any instruction on language development or language facilitation strategies. All spontaneous language sampling procedures were the same for the treatment and control families, and all language samples from the control families were retranscribed to eliminate the potential for investigator bias in the current study.

Participants

Nineteen families and their toddlers with typical development participated in the intervention. All children passed the communication section of the Ages and Stages Questionnaire–Third Edition (Squires & Bricker, 2009) administered during a phone interview at 20 months of age and were reported to produce at least 25 different words. Children were excluded if parents reported neurological or sensory impairments, delayed onset of walking or talking, or regular exposure to a language other than English. Children were also excluded if parents reported any use of four-word combinations, an indicator that expressive abilities were too advanced for the intervention. The children in the treatment group (11 girls and 8 boys) were matched to 19 children from an archival database (9 girls and 10 boys) on parent-reported expressive vocabulary at 21 months from the MacArthur–Bates Communicative Development Inventories (CDI; Fenson et al., 2007) and on sex and parent level of education, when possible.

All treatment families were White, non-Hispanic ($n = 19$). The age of parent participants (17 women and 2 men) was approximately 35 years ($M = 34.94$; $SD = 5.19$), 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 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 hr or less per week, four were in child care 6 to 29 hr per week, and eight were in child care 30 hr or more per week.

The majority of families in the control group were also White, non-Hispanic ($n = 15$). One family was White Hispanic, and three families were Black. The age of the parent participants (18 women and 1 man) was approximately 30 years ($M = 30.05$; $SD = 4.38$), 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 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 hr or less per week, five were in child care 6 to 29 hr per week, and six were in child care 30 hr or more per week.

Procedures

The procedures of the original investigation are summarized here (for full details, see Hadley et al., 2017). The parent instructional component involved three education sessions between the 21- and 24-month measurement sessions, one 1.5-hr group session and two 1-hr individualized coaching sessions. The group session was divided into three segments. In the first segment (approximately 20 min), information on language development between 18 and 30 months was presented, including characteristics of single-word users, word combiners, and childlike sentence users. In the second segment (approximately 40 min), information on responsive interaction strategies and general language modeling strategies were presented by using the *You Make the Difference* parent resource (Manolson, Ward, & Dodington, 2007) and instructional videos. During this segment, examples of expanding child utterances referred to as *adding language* in the parent resource were highlighted. However, alternative ways to expand child utterances using sentences were also presented.

{Direct parents' attention to example in the book}
The book suggests imitating *pretty* and then adding *flower*—*pretty flower*. You can also add *flower* in a short, complete sentence and use the expression in your voice to STRESS the two content words. *THE FLOWER is PRETTY*.

In the final segment (approximately 25 min), the two toy talk strategies (i.e., *talk about the toys*; *give the item its name*) were formally introduced by using handouts (Hadley & Rispoli, 2015) and demonstrations. Two investigators, with one playing the role of the child, demonstrated

responsive interaction strategies and toy talk during play with various toys (see below). Then, parents practiced the strategies through role play with the investigators and received feedback.

- C {holding up a puzzle piece} Cow.
A You found a cow.
= expansion, describes C's action
C {vocalizing, tries to put piece in}
A Help? {waits} Do you need help?
= interprets C's vocalization
C {puts cow in puzzle} Cow.
A The cow fits!
= expansion with toy talk (both strategies)
A {puts another piece in}
The pig goes in too.
C {feeds baby a bottle}
= A observes C
A You're feeding the baby.
= describes C's actions, gives toy its name
A The baby is drinking.
= toy talk (both strategies)
C Thirsty {points to teddybear}.
A Teddy looks thirsty.
= expansion with toy talk (both strategies)
A He wants a drink.
= talks about toy

A treatment fidelity checklist was used to document the delivery of 20 key instructional components for the 10 group education sessions. Two research assistants (RAs) who had not conducted the sessions completed the checklist. Point-by-point interobserver agreement for delivery of the 20 key components was 95.0% ($SD = 5.27\%$).

Coaching sessions began with a review of responsive interaction and toy talk strategies. Parents described their use of the two types of strategies at home, then engaged in 20 min of parent-toddler free-play. The first 10 min of free-play was video-recorded. An investigator then played the video recording for the parent on a laptop computer, pausing approximately once each minute to identify positive instances of the parent's strategy use and to offer constructive feedback on child-centered and interaction-promoting strategies, general language modeling strategies, and/or toy talk strategies. The investigator provided two to three specific suggestions for practice at home, and a written summary was sent by e-mail after the session. Feedback to parents on responding with short, well-formed sentences and using toy talk included 33.3% and 24.2% of the video feedback, respectively.

The measures of parent input and child outcomes were obtained from conversational language samples collected in two contexts. The first context included 30 min of parent-child free-play with age-appropriate toys. Parents were instructed to play with their children "as they would at home." For the second context, an investigator joined the parent-child dyad and used semistructured play scenarios to create opportunities for diverse verbs, sentence subjects, and T/A morphemes (see Hadley, 2014; Hadley et al., 2014,

2017; Oetting & Hadley, 2017). Transcription was completed by an unbiased team of undergraduate RAs who were unaware of the children's ages, treatment condition, toy talk strategies, and research questions. Language samples for the quasi-control group were also retranscribed alongside the language samples collected from the treatment group to eliminate investigator bias. All sessions were transcribed by using Systematic Analysis of Language Transcripts software (SALT; Miller & Iglesias, 2012). During a subsequent coding pass, RAs used computer-assisted searches to standardize spelling for NDW counts and added standard SALT conventions for all bound morphemes (e.g., *jump/ed*) and contractions (e.g., *he/s*) for parents and children. They also examined child utterances to exclude imitations, self-repetitions, and routine expressions (e.g., counting, lyrics) from further analyses.

Input Measures

Input measures were computed at 21 and 24 months from the child-directed, spontaneous, complete, and intelligible parent utterances produced in the first 30 min of the parent-child sampling context. Toy talk sentences with lexical NP subjects previously coded for Hadley et al. (2017) were also used in this study. Toy talk sentences met the following requirements. For syntax, clauses were required to be finite with canonical subject-verb-(object) word order as in 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?*). Grammatical subjects could be either common nouns (e.g., *The baby needs a bath*) or proper nouns (e.g., *Nina likes juice*). In addition, the referent of the subject was required to be present in the playroom or part of the pretend play (e.g., {mm} *This soup tastes good*). An explicit predicate was also required. Predicates could describe the states, actions, properties, locations, or possessions of the referential subject. From all sentences meeting these criteria, the number of different lexical NP subjects in toy talk sentences was determined, reflecting the diversity of NP subjects in parent input.

Parent input informativeness was computed following the procedures of Legate and Yang (2007) and Hadley et al. (2011). Verb forms marked unambiguously (i.e., overtly) for T/A morphemes were coded as +Tense [+T], and ambiguous forms were coded -Tense [-T]. The overtly marked verb forms included all regular and most irregular past tense (e.g., *The bubble popped*; *You did it*), present tense third person singular (e.g., *Danny love/s grapes*), and finite forms of copula BE and auxiliaries BE, DO, and HAVE. Auxiliary-main verb combinations received only one code (e.g., *What do you think?*). Ambiguous verb forms included irregular past tense verbs that do not change their surface form (e.g., *You put it away*), zero-marked present tense verbs (e.g., *I get the green one*), and modal auxiliaries (e.g., *can*, *will*, *should*). Bare verb forms, such as imperatives (e.g., *put your shoes on*), serial verbs (e.g., *go get your shoes*), and bare infinitives (e.g., *let's put them on*) were also coded -Tense. Infinitives overtly marked with *to* were not coded (e.g., *to blow*) nor were small clauses (e.g., *I see him playing*) because

these forms are distinctly nonfinite rather than ambiguous. Frequency counts of all +Tense and –Tense verb forms were summed for each parent, and input informativeness was computed as the percentage of overt +Tense forms out of all coded verb forms.

All parent uses of copula and auxiliary *is* and *'s* forms in spontaneous, complete, and intelligible utterances were extracted from the language transcripts, then coded for syntactic structure by a trained undergraduate volunteer. Five syntactic contexts were possible: declarative, *wh*-question, yes/no question, tag question, or ellipsis. Syntactic context coding was reviewed with the second author on a weekly basis, and all disagreements were resolved and corrected in the transcripts. Only full *is* declaratives were used for this study (e.g., *The baby is crying; this is a baby cow*). Declarative contexts were identified in main clauses and embedded clauses and included lexical NP subjects (e.g., *the baby*) and pronoun subjects (e.g., *this, there*).

Child Measures

Child measures were computed at the following sessions: 21, 24, 27, and 30 months. Children's NDW was computed automatically by SALT software for the 30-min parent–child sample. Additional coding and scoring procedures were required to compute the measures of sentence diversity and TAP. For these measures, 60 min of conversational interaction were used by combining the parent–child and the examiner–child–(parent) samples.

Children's declarative statements and structural questions with explicit subjects and lexical verb predicates in a finite clause were coded for sentence diversity (Hadley, 2006, 2014; Ingram, 1989; McKenna, 2013). The subject–verb combinations were further coded for person and number of the subject. Only sentences with third person singular or plural subjects and lexical verbs (e.g., *baby drinking; they fall down*) were used in this study because they allow lexical flexibility of both subjects and verbs (Hadley et al., 2017). Third person subjects can also appear as either pronouns or expanded NPs. Routine questions (e.g., *Where NP go/going?* or *What NP do/doing?*) were excluded because these utterances have the potential to be formulaic (Miller & Chapman, 1981). Sentences with a conversational partner in the initial position (e.g., *Mommy*) were excluded because it is often challenging to determine whether a partner name was used as an addressee term or as a sentence subject. Children were credited with unique combinations if the same grammatical subject was used with different verb stems (e.g., *baby need pillow; baby's going to you*), the same verb was used with different grammatical subjects (e.g., *fence fall over* vs. *they fall down*), or if subjects appeared in both singular and plural forms with the same verb (e.g., *baby need pillow* vs. *baby/s need a snack*).

Children's sentences were also scored for productive uses of T/A morphemes. All child sentences with copula BE, auxiliary BE, auxiliary DO, third person singular present tense /3s, and past tense regular /ed were extracted from the transcripts to compute a noncumulative TAP score at each

measurement point. The TAP score was designed to protect against the undue influence of rote and limited scope formulae by filtering out morphemes potentially produced by rote (Hadley et al., 2014; Hadley & Short, 2005; Rispoli, Hadley, & Holt, 2009). Uses of copula and auxiliary forms contracted to pronouns are excluded (e.g., *he's, it's, what's, where's, here's*) because these combinations are high frequency in the input and are packaged together as a single syllable (Li & Shirai, 2000; MacWhinney, 2000); however, forms contracted to noun subjects are allowed (e.g., *baby's going to you*). In addition, irregular forms (e.g., *went, has*) and negative contractions (e.g., *don't*) are excluded. Children received 1 point for each unique combination, up to a maximum of 5 points in each morpheme class. For copula and auxiliary forms, unique uses were based on different combinations of grammatical subjects and T/A morphemes, including the same subject with different T/A morphemes (e.g., *Where did it go? Does it fit?*) or different subjects with the same T/A morpheme (e.g., *This is mine; farm is right there*). Verb affixes /3s and /ed were counted as unique uses if they appeared with different verb stems, including overregularizations on irregular verb stems (e.g., *broke/ed, have/3s*).

Reliability

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. 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 five 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 nine transcripts required a consensus pass at 27 and 30 months of age.

Twelve transcripts (six treatment and six control), were randomly selected and coded independently for adult toy talk and input informativeness by a second RA. For toy talk, coders were required to make decisions about whether an utterance was coded as toy talk with a NP subject, pronominal subject, 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). For input informativeness, the percentage agreement was computed between the codes from the original and reliability transcripts. Mean agreement was 96.0% (range = 92% to 99%). Given the high levels of agreement, data analysis for input informativeness was based on the original coder's transcript.

Given the low frequency with which full *is* declaratives were produced, syntactic context coding for all full

is forms was reviewed by the first author. Eight coding errors out of 1,972 *is* uses (0.4%) were identified and corrected.

Independent reliability was reported for children's sentence diversity in Hadley et al. (2017). Sentence diversity measures were independently computed by a second RA for six randomly selected child participants at 21, 24, 27, and 30 months. Agreement was based on the coding of sentences with all subject-verb codes. A total of 618 child subject-verb codes were compared, resulting in a Cohen's κ of .94. For this study, TAP scores were verified through consensus procedures. All original scoring decisions for every transcript were checked by a second coder. The second coder was in complete agreement with the original coder for 142 (88.8) of the 160 transcripts. For the 18 transcripts with disagreements, 17 had only one scoring decision difference. All scoring disagreements were resolved and corrected prior to data analysis.

Data Analysis

To address the first research question, we examined change in parents' use of input informativeness and the use of full copula and auxiliary *is* forms in declaratives as a function of Condition (treatment vs. control) before and after instruction. Repeated measures analyses of variance (ANOVAs) were used with Condition as a between-participants factor and Time as a within factor. An interaction effect was expected with treatment parents providing more informative input for tense and producing more full *is* declaratives than control parents after instruction.

For the second research question, hierarchical linear modeling was used to analyze developmental change in children's TAP scores and to identify predictors of growth from 21 to 30 months (Holt, 2008; Raudenbush & Bryk, 2002; Raudenbush, Bryk, & Congdon, 2007). When applied to the study of longitudinal change, hierarchical linear 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 children's growth trajectories. Because we expected the instruction to exert its effect on sentence diversity by approximately 27 months, and subsequently on TAP, equations for TAP growth were age centered at 30 months. Once the best-fit growth model was determined, a random slopes model was fit to allow TAP growth trajectories between 21 and 30 months to vary randomly across participants. This allowed for estimating the growth trajectory for the full group of 38 participants, as well as the individual differences from the overall growth trajectory. In addition, we explored developmental and input predictors of children's growth rates. Developmental effects would be evident if children's NDW and/or sentence diversity were significant predictors of children's ability to produce sentences marked for tense and agreement. Input effects would be evident if parent input variables were significant predictors of children's TAP growth rates. Recall that Hadley et al. (2017) found a significant input effect for individual

parents' use of lexical NP subjects on their children's growth in sentence diversity but only a marginal treatment effect between the treatment and control groups. Therefore, the analyses of input variables in this study were also conducted at the level of the individual parent-toddler dyads collapsing across the two groups. In other words, if the intervention altered T/A properties of parent input as expected, variability in these input properties would expand in the full sample. If so, the analyses conducted on the full sample would allow us to determine which specific input properties were significant predictors, or active ingredients, of children's grammatical growth.

Results

Treatment Effects on Parent Input Informativeness and Full *is* Declaratives

Our first question focused on the indirect benefits of toy talk instruction on parents' T/A marking, in general, and their use of full copula and auxiliary *is* forms, in particular. Descriptive statistics for lexical NP subject diversity, +Tense and -Tense verb forms, input informativeness, and full *is* declaratives are reported in Table 1 for parents in the treatment and control conditions prior to instruction at 21 months and following instruction at 24 months. At 21 months, there were no group differences for any parent input measure all $ps \geq .581$.

Given the increased frequency of toy talk sentences with third person subjects following instruction reported in Hadley et al. (2017), we predicted a related increase in input informativeness. However, toy talk instruction did not alter treatment parents' percentage of informative input sentences. The treatment and control groups produced the

Table 1. Means and standard deviations for parent input measures by time and condition.

Measure	Control		Treatment		Full sample	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Lexical NP subject diversity						
21 months	4.68	3.04	5.58	2.84	5.13	2.93
24 months	6.00	2.96	18.05	9.99	12.03	9.49
+Tense verb forms						
21 months	148.05	57.25	157.42	51.12	152.74	53.74
24 months	167.79	59.76	161.37	54.48	164.58	56.50
-Tense verb forms						
21 months	136.21	53.73	136.11	54.31	136.16	53.29
24 months	136.95	59.10	126.42	36.26	131.68	48.65
Input informativeness						
21 months	52.42	10.69	54.13	8.08	53.27	9.38
24 months	55.66	9.14	55.60	6.63	55.63	7.88
Full <i>is</i> declaratives						
21 months	3.32	3.92	2.74	2.56	3.03	3.28
24 months	5.53	5.37	13.74	10.38	9.63	9.15

Note. Control $n = 19$; treatment $n = 19$; full sample $N = 38$. NP = noun phrase.

same average percentage of input sentences with overt T/A marking (treatment, $M = 55.6\%$; control, $M = 55.7\%$). A repeated measures ANOVA revealed no significant main effects for Condition, $F(1, 36) = 0.11, p = .743, \eta_p^2 = .003$, or for the Time $\times$ Condition interaction, $F(1, 36) = 0.44, p = .513, \eta_p^2 = .01$, although the main effect for Time approached significance, $F(1, 36) = 3.08, p = .09, \eta_p^2 = .08$.

Toy talk instruction was also predicted to alter full copula and auxiliary *is* forms in declarative contexts because full *is* declaratives are more likely with lower frequency grammatical subjects (Frank & Jaeger, 2008), such as those found in toy talk input sentences. This prediction was supported. Instruction magnified the treatment group's production of full *is* declaratives, increasing their average production from 2.74 to 13.74 instances in 30 min of parent-child interaction (see Table 1). A repeated measures ANOVA for full *is* declaratives revealed significant main effects for Condition, $F(1, 36) = 5.81, p = .02, \eta_p^2 = .14$, for Time, $F(1, 36) = 26.23, p < .001, \eta_p^2 = .42$, and for the Time $\times$ Condition interaction, $F(1, 36) = 11.61, p = .002, \eta_p^2 = .24$.

For the final adult analysis, we examined associations between lexical NP subject diversity, the input measure altered as a direct result of toy talk instruction (Hadley et al., 2017), with the input variables predicted to change as indirect benefits of instruction (see Table 2). Correlational analyses for the full sample revealed that lexical NP subject diversity was positively associated with +Tense verb forms, $r = .45, p = .003$, and with full *is* in declarative contexts, $r = .78, p < .001$, but not with -Tense verb forms nor with input informativeness, $r = .22, p = .09$. Also, only full *is* declaratives were related to children's 30-month TAP scores, $r = .29, p = .041$.

Growth in Children's T/A Marking

Descriptive statistics for children's MLU, NDW, third person sentence diversity, and TAP scores by measurement point are reported in Table 3 by condition and for the full sample, because the growth analyses were conducted on the full sample. Recall that child participants

were required to be typically developing but not too advanced to participate in the intervention. At 21 months, child participants in both conditions had MLUs in the below average to average range, relative to the expectations of Miller and Chapman (1981; i.e., $M = 1.62, SD = 0.39$). Note that there were no significant group differences for any child variables at 21 months, reducing the likelihood that the parent changes observed were attributable to initial child characteristics. However, because the differences in NDW approached significance, $t(36) = -1.77, p = .09$, this variable was used as a time-varying covariate in the growth analyses.

Developmental change in the TAP score was modeled according to Equation 1. In this equation, $TAP\ score_{ti}$ is the observed score 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 30 months (the centering point), and π_{1i} is the linear rate of change for individual i at the centering point of 30 months, interpreted as the instantaneous rate of linear change at 30 months. The quadratic growth parameter, π_{2i} , reflects the curvature or acceleration or deceleration in each child's overall growth across time. Larger positive values of π_{2i} imply more rapid growth in the TAP score. Successive models were compared with one another to determine the best fit to the data. Using likelihood ratio tests, the deviance of each successive growth model was compared with the more restricted model. These tests were conducted by using the full information maximum likelihood estimation.

$$\begin{aligned} TAP_{ti} &= \pi_{0i} + \pi_{1i} (age_{ti} - 30) + \pi_{2i} (age_{ti} - 30)^2 + e_{ti} \\ \pi_{0i} &= b_{00} + r_{0i} \quad \pi_{1i} = b_{10} + r_{1i} \\ \pi_{1i} &= b_{20} + r_{2i} \\ \pi_{2i} &= b_{20} + r_{2i} \end{aligned} \quad (1)$$

A linear growth trajectory was examined and tested for its difference from the unconditional means model. The linear model was a statistically significant better fit than the unconditional means model, $\chi^2(3) = 153.00, p < .001$. The estimates indicated that the fixed linear coefficient and the between-child variability in linear growth were both statistically significant (see Model 1, Table 4). That is, the linear increase in the TAP score was significantly different from 0, $b_{10} = 0.78, p < .001$, 95% confidence interval (CI) [0.60, 0.96], indicating growth of .78 T/A morphemes per month for the group with significant variability in linear growth among children (i.e., $VAR(r_1) = 0.22$). The intercept was also significantly different from 0, $b_{00} = 6.45, p < .001$, 95% CI [4.99, 7.90], with significant variability in the intercept remaining among children (i.e., $VAR(r_0) = 17.03$).

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,

Table 2. Correlations for 24-month parent input measures and 30-month child tense agreement productivity score.

Adult input measures	2	3	4	5	Child TAP score
1. Lexical NP subject diversity	.45**	.19	.20	.78***	.22
2. +Tense verb forms		.52***	.41**	.33*	.19
3. -Tense verb forms			-.53***	.07	.06
4. Input informativeness				.22	.04
5. Full <i>is</i> declarative					.29*

Note. $N = 38$. TAP = tense agreement productivity; NP = noun phrase.

* $p < .05$ (one-tailed). ** $p < .01$ (one-tailed). *** $p < .001$ (one-tailed).

Table 3. Descriptive statistics for child measures by condition and full sample by measurement point.

Parameter	Control		Treatment		Full	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
MLU						
21 months	1.20	0.22	1.23	0.22	1.22	0.21
24 months	1.55	0.46	1.52	0.48	1.53	0.46
27 months	1.93	0.48	1.95	0.47	1.94	0.47
30 months	2.26	0.48	2.34	0.66	2.30	0.57
NDW						
21 months	18.53	12.38	26.11	14.02	22.32	13.56
24 months	47.11	25.91	52.26	18.95	49.68	22.54
27 months	75.11	31.64	79.37	25.03	77.24	28.22
30 months	91.79	25.36	102.00	36.35	96.89	31.36
Sentence diversity (in third person sentences)						
21 months	0.16	0.69	0.37	0.68	0.26	0.68
24 months	2.11	3.13	2.47	2.50	2.39	2.89
27 months	6.00	4.87	5.11	4.31	6.05	4.90
30 months	9.58	6.23	12.79	8.00	12.21	7.91
Tense and agreement productivity score						
21 months	0.11	0.46	0.32	0.67	0.21	0.57
24 months	1.63	2.36	1.05	1.75	1.34	2.10
27 months	4.11	3.80	2.74	2.83	3.47	3.45
30 months	6.53	4.97	8.16	5.28	7.42	5.12

Note. Control group $n = 19$; treatment group $n = 19$; full sample $N = 38$. MLU = mean length of utterance; NDW = number of different words.

$\chi^2(4) = 53.05$, $p < .001$. In addition, the test of the homogeneity of variance in the residuals was no longer significant in the quadratic model $\chi^2(35) = 10.18$, $p > .5$. These findings indicated that a quadratic model was the optimal model to characterize growth in children's TAP scores over time.

The quadratic model had a statistically significant intercept, indicating that the TAP score was significantly different from 0 at 30 months, $b_{00} = 7.00$, $p < .001$, 95% CI [5.44, 8.55], a statistically significant linear term, indicating that the linear growth rate at 30 months was significantly

different from 0, $b_{10} = 1.44$, $p < .001$, 95% CI [0.98, 1.91], and the quadratic trajectory from 21 to 30 months was also statistically significant, $b_{20} = 0.08$, $p < .001$, 95% CI [0.03, 0.12] (see Model 2, Table 4). Model 2 indicated that the average child in this sample produced seven unique T/A morphemes with significant linear growth at 30 months and overall acceleration. There was also significant variability among children for all three growth components: for intercept, $\text{VAR}(r_0) = 21.12$, $p < .001$, linear growth, $\text{VAR}(r_1) = 1.62$, $p < .001$, and quadratic growth, $\text{VAR}(r_2) = 0.01$, $p < .001$, respectively.

Table 4. Children's tense agreement productivity score growth models.

Effects	Model 1 linear	Model 2 quadratic	Model 3 quadratic with NDW	Model 4 quadratic with NDW, sentence diversity
Fixed effects				
Intercept, b_{00}	6.45**	7.00**	5.71**	5.06**
Linear growth, b_{10}	0.78**	1.44**	1.19**	0.86**
Quadratic growth, b_{20}		0.08**	0.08**	0.06*
NDW, b_{30}			0.04**	0.02
Sentence diversity, b_{40}				0.20**
Random effects				
Intercept, $\text{VAR}(r_0)$	17.03**	21.12**	18.99**	14.61**
Linear growth, $\text{VAR}(r_1)$	0.22**	1.62**	1.44**	0.94**
Quadratic growth, $\text{VAR}(r_2)$		0.01**	0.011**	0.008**
Level 1, $\text{VAR}(e)$	3.87	1.52	1.37	1.35

Note. $N = 38$. Models age centered at 30 months. NDW = number of different words.

* $p < .01$ (two-tailed). ** $p < .001$ (two-tailed).

Developmental Predictors of Children's Growth in TAP

The next two models examined whether measures of children's growth in NDW and sentence diversity would improve the within-child estimation of TAP growth. Given that TAP scoring criteria require T/A morphemes to be used with different subjects and verbs, we expected the diversity measures to improve the estimation of TAP growth. However, we expected sentence diversity, requiring lexical flexibility with basic clause structure, to be the primary predictor of children's ability to mark sentences with tense and agreement because tense and agreement are properties of clauses, not words.

Children's NDW and sentence diversity from 21 to 30 months were group mean centered and included as time-varying covariates (see Equations 2 and 3, respectively) to determine if spontaneous use of diverse words and subject-verb combinations were significant predictors of TAP growth. To reduce the complexity of the model relative to the sample size, NDW and sentence diversity were estimated as fixed coefficients, although all the growth parameters were allowed to randomly vary across individuals.

$$TAP_{ti} = \pi_{0i} + \pi_{1i} (age_{ti} - 30) + \pi_{2i} (age_{ti} - 30)^2 + \pi_{3i} (NDW)_{ti} + e_{ti} \quad (2)$$

$$TAP_{ti} = \pi_{0i} + \pi_{1i} (age_{ti} - 30) + \pi_{2i} (age_{ti} - 30)^2 + \pi_{3i} (NDW)_{ti} + \pi_{4i} (SenDiv)_{ti} + e_{ti} \quad (3)$$

Children's NDW was a statistically significant predictor of TAP trajectories over time, $b_{30} = 0.04$, $p < .001$, 95% CI [0.02, 0.05]. This indicates that TAP scores increased by .04 points with each different word produced or by 1 point with every 25 different words. The addition of NDW in Model 3 accounted for an additional 10.4% of the within-child error variance in TAP growth (see Table 4). As reported in Model 4, sentence diversity was also a statistically significant predictor of TAP growth over time, $b_{40} = 0.20$, $p < .001$, 95% CI [0.11, 0.29] (see Table 4). This indicates that TAP scores increased by .20 points with each unique combination of third person subjects and verbs, or by 1 point with every five different sentences. Furthermore, once sentence diversity was added, NDW was no longer a significant predictor of TAP growth, $b_{30} = 0.02$, $p = .21$, 95% CI [-0.002, 0.04].

Input Predictors of Children's Growth in TAP

To identify the contribution of parent input to children's TAP growth, the three input variables from the 24-month measurement point were grand mean centered and added as Level 2 predictors in three parallel models (see Equation 4). Model 5a examined the effects of input informativeness (i.e., percentage of verb forms marked overtly for tense and agreement); Model 5b examined the effects of input subject diversity (i.e., number of different

lexical NP subjects); and Model 5c examined the effects of full *is* declaratives.

$$\begin{aligned} TAP_{ti} = & \pi_{0i} + \pi_{1i} (age_{ti} - 30) + \pi_{2i} (age_{ti} - 30)^2 \\ & + \pi_{3i} (NDW)_{ti} + \pi_{4i} (SenDiv)_{ti} + e_{ti} \\ \pi_{0i} = & b_{00} + b_{01} (Input\ Variable24)_i + r_{0i} \\ \pi_{1i} = & b_{10} + b_{11} (Input\ Variable24)_i + r_{1i} \\ \pi_{2i} = & b_{20} + b_{21} (Input\ Variable24)_i + r_{2i} \\ \pi_{3i} = & b_{30} + b_{31} (Input\ Variable24)_i \\ \pi_{4i} = & b_{40} + b_{41} (Input\ Variable24)_i \end{aligned} \quad (4)$$

Parents' input informativeness was not a significant predictor of any component of children's TAP growth trajectories, all $p > .28$ (see Table 5, Model 5a). However, parents' lexical NP subject diversity and the frequency of their full *is* declaratives were both significant predictors of TAP growth, albeit for different growth components. Model 5b identified lexical NP subject diversity as a significant predictor of linear growth in TAP scores at 30 months, $b_{11} = 0.05$, $p = .032$, 95% CI [0.005, 0.10], and quadratic growth, $b_{21} = 0.004$, $p = .037$, 95% CI [0.0003, 0.008] (see Table 5). That is, parents' input subject diversity accounted for 10.4% of the between-child variance in linear growth and 12.8% of the between-child variance in quadratic growth. The linear coefficient of .05 indicates that for every 20 different lexical NP subjects in parent input at 24 months, children's TAP scores at 30 months increased by one morpheme per month. The quadratic coefficient of .004 indicates that the number of different lexical NP subjects was associated with acceleration in TAP growth between 21 and 30 months. A median split was used to illustrate the effect of high versus low parent input subject diversity on children's TAP growth (see Figure 1). The full sample was divided at the median of 8.50, with the vast majority of treatment parents falling above the median (i.e., 16 of 19). Model 5c revealed that parents' frequency of full *is* declaratives was also a significant predictor of TAP intercept at 30 months, $b_{01} = 0.17$, $p = .033$, 95% CI [0.00, 0.34], as well as linear growth in TAP scores at 30 months, $b_{11} = 0.05$, $p = .031$, 95% CI [0.005, 0.10] (see Table 5). Full *is* declaratives accounted for 8.2%, and 14.0% of the between-child variance in estimates of the intercept and linear growth, respectively. As a significant predictor of TAP status at 30 months, approximately every six parent uses of full *is* declaratives at the 24-month measurement point increased a child's 30-month TAP score by approximately 1 point. The linear coefficient of .05 indicates that for every 20 full *is* declaratives, children's TAP scores increased by one morpheme per month. Figure 2 illustrates the effects of parent differences in full *is* declaratives on children's TAP growth for parents above and below the full sample median of 6.50. On this input variable, 68.4% of the treatment parents were above the median (i.e., 13 of 19). In both Models 5b and 5c, the fixed effects for intercept, linear growth, and quadratic growth remained statistically significant after controlling for the developmental and input predictors (see Table 5). Likewise, significant random variation remained

Table 5. Input predictors of children's tense agreement productivity growth.

Effects	Model 5a input informativeness	Model 5b lexical NP subject diversity	Model 5c full <i>is</i> declarative
Fixed effects			
Intercept	5.14***	5.15***	5.06***
Input informativeness	5.83		
Lexical NP subject diversity		0.12	
Full <i>is</i> declarative			0.17*
Linear growth	0.90***	0.90***	0.87***
Input informativeness	2.89		
Lexical NP subject diversity		0.05*	
Full <i>is</i> declarative			0.05*
Quadratic growth	0.06**	0.06**	0.06**
Input informativeness	0.24		
Lexical NP subject diversity		0.004*	
Full <i>is</i> declarative			0.003
NDW	0.02 [†]	0.02 [†]	0.02*
Input informativeness	0.04		
Lexical NP subject diversity		-0.00009	
Full <i>is</i> declarative			-0.001
Sentence diversity	0.19***	0.19***	0.19***
Input informativeness	-0.71		
Lexical NP subject diversity		-0.004	
Full <i>is</i> declarative			-0.0004
Random effects			
Intercept, VAR(r_0)	15.32***	14.28*	13.41***
Linear growth, VAR(r_1)	0.98***	0.84***	0.81***
Quadratic growth, VAR(r_2)	0.008***	0.007***	0.007***
Level 1 error, VAR(e)	1.30	1.30	1.32

Note. $N = 38$. Model age centered at 30 months. NP = noun phrase.

* $p < .05$ (two-tailed). ** $p < .01$ (two-tailed). *** $p < .001$ (two-tailed). [†] $p < .10$ (two-tailed).

in all growth parameters for Models 5b and 5c, with significant between-child variation.

In summary, toy talk instruction modified parent input in both direct and indirect ways. In the original study, Hadley et al. (2017) documented that treatment parents,

relative to control parents, significantly increased their use of lexical NP subjects as a direct result of instruction. The current study documents indirect benefits as well. Treatment parents used more acoustically salient, full *is* declaratives than control parents, without any explicit instruction

Figure 1. Differences in tense agreement productivity growth trajectories from 21 to 30 months, controlling for children's number of different words and sentence diversity, with median split on number of different lexical noun phrase subjects. **Figure 2.** Differences in tense agreement productivity growth trajectories from 21 to 30 months, controlling for children's number of different words and sentence diversity, with median split on full *is* declaratives.

on T/A morphemes. Two input variables, lexical NP subject diversity and full *is* declaratives, were also significant predictors of between-child differences in TAP growth, together with developmental change in sentence diversity from 21 to 30 months.

Discussion

This study provides the first evidence that modifying lexical NP subject diversity in parents' declarative input sentences promotes children's growth in T/A morphemes, along with growth in sentence diversity. In this discussion, we address the significance of the findings, the limitations of the study, and future directions for clinical research and practice.

Toy Talk Instruction and T/A Morphemes in Parent Input

Recall that toy talk instruction altered parent use of lexical NP subjects in declarative sentences by teaching parents two simple strategies, talk about the toys and give the object its name (Hadley et al., 2017). This study explored whether toy talk instruction also had indirect benefits on parents' use of T/A morphemes. The lack of change in input informativeness in this study differed from an earlier feasibility study (Hadley & Walsh, 2014) in which both lexical NP subjects and input informativeness were altered. Methodological differences may explain the different results. In the feasibility study, 2.5-min silent video clips of parent-child play were used to assess change in language input, with the adult participants talking for the parent in the video before and immediately after 15 min of toy talk instruction. This method allowed participants to think about their input without the added challenge of engaging a child in play. In contrast, the parents in this study received instruction on more strategies over a longer period. Parent instruction focused on both responsive interaction strategies and language modeling strategies, and the measures of language input were based on 30 min of parent-child free-play obtained several weeks after the last instructional session. The additional task demands of engaging children in play while using toy talk strategies may explain the lack of change in input informativeness. That is, utterances that direct young children's attention and behavior typically take the form of imperatives with ambiguous, -Tense verb forms (e.g., *Look at this; drink your juice; let's eat*). Thus, modest increases in object-focused, descriptive talk were insufficient to offset frequent use of imperative verb forms (Fitzgerald et al., 2013).

On the other hand, toy talk instruction did change the way T/A morphemes were packaged in parent input. Following instruction, parents in the treatment group produced more full *is* declaratives than parents in the control group. Correlational analyses also revealed a positive, moderately strong association between lexical NP diversity and the frequency of full *is* declaratives. Collapsing across parents in each group, treatment parents produced 261 full *is* declaratives, with 65.1 of these forms (170 of

261) appearing with lexical NP subjects. In comparison, control parents produced 104 full *is* declaratives, with only 20.2% (21 of 104) appearing with lexical NP subjects. Control parents produced the majority (48 of 104) of full *is* declaratives in phonologically uncontractible contexts, primarily with the subject pronoun *this* (e.g., *This is a cow*). In addition, when producing lexical NP subjects in contractible contexts, treatment parents were twice as likely as control parents to produce full *is* declaratives (61.5% vs. 31.0%) as opposed to contracted 's forms. Although the change observed in parents' production of full *is* declaratives was consistent with our a priori prediction, parents were also encouraged to slow down their rate of speech and to stress content words. This may have influenced their use of full *is* declaratives as well. Future research is needed to distinguish between these two possibilities.

Developmental and Input Predictors of Growth in Tense and Agreement

Our second research question explored how children's developmental abilities and parents' input worked together to facilitate the growth of tense and agreement. Given the mounting evidence for stability in language development (Bornstein, Hahn, & Putnick, 2016; Bornstein, Hahn, Putnick, & Suwalsky, 2014) and the potential for children's developmental levels to influence the input they receive (e.g., Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010), we included both children's NDW and sentence diversity as time-varying covariates in the model-building process before exploring the contribution of parent input to morphosyntactic growth. With both types of diversity in the growth model, NDW was not a significant predictor of TAP growth trajectories, but growth in sentence diversity was. For every five different subject-verb combinations, TAP scores increased by 1 point. This finding demonstrates that children's knowledge of clause structure, as predicted, contributes to the acquisition of the T/A system.

The empirical link established between children's growth in sentence diversity and TAP is consistent with the predictions of gradual morphosyntactic learning (Rispoli & Hadley, 2011; Rispoli et al., 2012), an account that emphasizes the role of sentence diversity in morphosyntactic development. Gradual morphosyntactic learning posits that children's production of increasingly diverse sentences with lower frequency subjects and verbs is an important indicator of their ability to generate sentences with an internal representation of abstract grammatical relations and clause structure. In addition, diverse subjects, distributed across the grammatical features of person and number, provide opportunities to encode subject-verb agreement with different surface forms (e.g., *I am* vs. *the penguin is; the blocks are*), and diverse verbs provide opportunities to encode the interaction between aspect and tense (e.g., *is eating* vs. *tastes*; Hadley, Rispoli, & Hsu, 2016; Rispoli et al., 2012).

The current findings also provide new insights about stability in language growth over time. Children's ability

to learn words and grammatical patterns from language input is clearly influenced by what they already know. For example, Fernald and Marchman (2011) have demonstrated that between-child differences in vocabulary knowledge at 18 months influence how efficiently children comprehend words in language input and that differences in the processing efficiency of familiar words confer an advantage on subsequent expressive vocabulary growth. Vocabulary knowledge also provides a foundation for learning and producing basic syntactic structure (Connor, Fisher, & Roth, 2013; Hadley et al., 2017). This study demonstrates that the strength of children's clausal representations, as indicated by the lexical flexibility of subject–verb combinations, contributes to the acquisition of the T/A system.

Empirical support for the hypothesized input predictors was mixed. Although parents exhibited variation in input informativeness, ranging from 36.3% to 68.5%, this input property was not a significant predictor of children's TAP growth. The failure to replicate the previous findings of Hadley et al. (2011) may have been related, in part, to the inclusion of the two developmental time-varying covariates. This nonsignificant finding also points to the possibility that quality may outweigh quantity in the competition between overt and ambiguous signals of tense marking. In particular, not all overt markings of tense may be equally helpful. On the other hand, this study replicated the average input informativeness previously reported for English child-directed speech. In the full sample, verb forms were marked overtly 55.6% of the time, comparable to values previously reported by Legate and Yang (2007) and Hadley et al. (2011). The substantial ambiguity of English verb forms in naturally occurring conversational input (i.e., 44.4%) underscores why this grammatical system is challenging to acquire.

On the other hand, two rare properties of parent input at 24 months, lexical NP subject diversity and full *is* forms in declarative sentences, were significant predictors of children's TAP growth. Lexical NP subjects in declarative sentences accounted for 10.4% of input sentences for treatment parents and less than 3% of input sentences for the control parents. Full *is* declaratives were even less common, occurring in 3.6% of input sentences for treatment parents and less than 1% of input sentences for control parents. However, both rare input properties predicted linear growth in TAP scores at 30 months. In addition, lexical NP subject diversity explained additional variance in overall acceleration, and full *is* declaratives explained additional variance in the intercept at 30 months. We expected parents' use of full *is* declaratives to increase children's ability to identify the word *is* in the input by increasing its phonetic substance (Pinker, 1984), especially because copula *is* is the most frequent T/A morpheme appearing in parent input (Fitzgerald et al., 2013; Rispoli & Hadley, 2014). In turn, we expected children's acquisition of copula *is* to promote the growth of other T/A morphemes through cross-morpheme facilitation (Rispoli, 2016). On the other hand, we expected parents' lexical NP subjects to exert their effect primarily through the strengthening of children's clause structure.

However, parents' lexical NP subject diversity also influenced TAP growth, even after controlling for children's sentence diversity. The additional effect of lexical NP subject diversity may be related to its positive correlation with full *is* declaratives. Parents who used additional different lexical NPs as subjects also produced more full copula and auxiliary *is* forms in declaratives.

Why might toy talk input sentences with both lexical NP subjects and full *is* forms be particularly facilitative? It is possible that these declarative input sentences combine multiple cues to clause structure in a powerful way. As outlined in the introduction, declarative sentences with lexical NP subjects align low transitional probabilities between the noun and the following verb with prosodic cues to a key constituent boundary: the separation of subject from predicate. As the representation of clause structure is strengthened, children should be better able to detect T/A morphemes in input sentences. When lexical NP subjects are combined with full *is* forms, morpheme identification may be enhanced in two ways, by the phonetic substance of *is* as a word (cf. *It's hot* → *The egg is hot*; *He's running* → *The dog is running*) and by situating the morpheme prosodically in the predicate. For example, in the input sentences *The egg is hot* and *The dog is running*, the unstressed *is* falls in the phonological phrase with *hot* and *running* (Gerken & McGregor, 1998). In contrast, prosodic structure and subject–predicate constituent structure are not as well aligned in sentences such as *This is an egg* and *He's running*. In these sentences, the T/A morpheme is situated prosodically with the subject, disguising the subject–predicate boundary. From this perspective, input sentences with noun subjects improve the reliability of prosodic cues available to children for detecting morphemes and constituent structure. In addition, optimal alignment of constituent structure and prosodic structure occurs when the input sentence is derivationally simple, with declarative sentence structure. Structural questions with subject–auxiliary inversion lack this alignment, insofar as T/A morphemes are moved out of the predicate and toward the periphery of the sentence.

Given that parents' lexical NP subjects and full *is* declaratives were both coded only in declarative sentences, it is important to point out that the coding schemes had several other distinctive elements. That is, toy talk sentences with lexical NP subjects could occur with lexical verbs, modal auxiliaries, or any copula or auxiliary BE form. Likewise, full *is* declaratives could occur with any noun or pronoun subject, regardless of whether the subject referred to a concrete referent in the playroom, was used in existential sentences (e.g., *Here is your cup*), or was used to label objects (e.g., *This is broccoli*). Thus, the coding schemes used in this study considered the two input properties separately. Future investigations could explore the contribution of these two rare input properties operating in tandem.

Design Limitations

Despite the intriguing new input effects revealed, several design limitations must be recognized. First, a

quasi-control group was used to evaluate changes in parent input properties. This design element was deemed a cost-effective approach for an initial investigation of a new input variable. Second, parent educational levels and racial or ethnic diversity were not well balanced between the treatment and quasi-control groups. The demographic differences raise concerns regarding the generalizability of the instructional procedures to more culturally, linguistically, and socioeconomically diverse families (see Hadley et al., 2017, for discussion) and warrant further evaluation of the feasibility and efficacy of the low-intensity instructional procedures with more diverse families. At the same time, the demographic differences between groups are less likely to have influenced the primary findings of this study because input effects were examined at the level of individual parent-toddler dyads rather than as a function of treatment condition. In addition, no direct instruction was provided to either group regarding use of T/A morphemes. Third, it is difficult to disentangle the contribution of parents' lexical NP subject diversity and full *is* forms in declarative contexts because these input properties were correlated. Given that these input properties occurred at such low frequencies, it will be necessary to increase input subject diversity beyond the rates produced in this study to decouple the contribution of these distinct input properties. Additional factors should also be examined in future studies. For example, children's abilities to parse and comprehend language input in real time plays a substantial role in the extent to which children can make use of the grammatical properties of input (e.g., Lew-Williams & Fernald, 2007). Additional properties of responsive interaction and language input strategies, such as expansions and recasting, should be examined to characterize the nature of optimal input sentences for facilitating grammatical development, in general, and the onset of tense and agreement, in particular.

Clinical Implications

Although this study was conducted with toddlers with slow typical development, the findings have implications for clinical interventions for preschool children with SLI. The most important empirical finding is that children's sentence diversity was a significant predictor of children's acquisition of tense and agreement. If the same relationship holds for children with SLI, intervention activities designed to promote more flexible use of known words in diverse subject-verb combinations could be conceptualized as a preventative approach for addressing the morphosyntactic weaknesses commonly observed in children with SLI. The plausibility of this proposal is strengthened by the converging evidence linking subject-verb combinations and morphosyntactic growth in this study and in Pawłowska et al. (2008), despite methodological differences in the computations of subject-verb combinations. Pawłowska et al. (2008) used the percentage of clauses with lexical verbs and subjects from a 100-utterance pretreatment language sample. Subjects could be first, second, or third person, and

repetitions were allowed. Imperatives were included in the total number of clauses with lexical verbs, even though they did not obligate the use of a subject. In contrast, our measure focused on unique third person subject-verb combinations assessed from 60-min language samples collected at 3-month intervals over a 9-month period. Third person sentences were of primary interest because T/A morphemes commonly appear first in this sentence context (Hadley, 2006; Hadley & Short, 2005; Rispoli et al., 2012) and because input subject diversity can only be manipulated in this sentence context. Together, the converging evidence suggests that lexical flexibility with basic sentence structure is important to establish prior to initiating intervention focused on the emergence of T/A morphemes. Future clinical research studies are needed to determine whether efforts to increase sentence diversity prior to targeting the emergence of T/A morphemes would improve the efficiency of morphosyntactic interventions.

The current study also contributes to a growing body of work documenting the beneficial effects of input diversity on language development (Hsu, Hadley, & Rispoli, 2017; Plante et al., 2014; Rowe, 2012). In Plante et al. (2014), the investigators manipulated verb input diversity as part of a clinical intervention for children with SLI. They demonstrated that recasting grammatical morphemes by using twice as many different verbs facilitated the acquisition of grammatical morphemes, including both auxiliaries that appear before the verb and suffixes that follow it. In this study, parents' input subject diversity promoted children's growth of sentence diversity and T/A morphemes. Together, these studies demonstrate that input diversity for open-class items supports children's analysis of closed-class items, such as T/A morphemes.

These findings raise important clinical issues about how to balance the presentation of diverse nouns in subject position in language input, while also providing platform utterances that children will comprehend easily and spontaneously imitate more readily. However, increasing input subject diversity does not require exposing children to unfamiliar, low-frequency words. Rather, nouns from a child's expressive vocabulary can be presented in subject position. The following examples from Parents 5 and 6 illustrate how children's single words were expanded into toy talk sentences. The example from Parent 9 begins with an ordinary expansion in which the noun *glasses* occupies the direct object position of the verb phrase, followed by additional description about the glasses. In Parent 9's next turn, the noun *glasses* is promoted to subject position. The example from Parent 18 illustrates the natural tendency to produce pronouns in subject position. We explained this to parents as the way language works and encouraged them to "give the item its name" in a following utterance if they responded first with a pronoun. In this case, Parent 18 first used the pronoun *he* and later *the bug*. Note that the child incorporated the parent's noun as the subject for his next utterance, *bug alright*, and then the parent recast the childlike utterance into an adult sentence, *the bug's alright*.

- Parent 5 C Stuck.
C Stuck.
M Stuck, yeah.
M These plates are stuck together.
- Parent 6 C Penguin.

M The penguin fell down.
- Parent 9 C Glasses on
M Put his glasses on?
C xxx.
M These glasses are green.
- Parent 18 M {woah} He crashed.

M I think he needs help.
C xx xx.
M The bug needs help.
C Bug alright.
M The bug's alright.

Conclusions

The current study identified two new properties of language input that facilitate children's acquisition of grammar. In particular, the diversity of parents' lexical NP subjects and their use of full *is* forms in declarative input sentences promoted the growth of tense and agreement. These properties appear to increase the availability and alignment of cues to constituent structure, facilitating children's acquisition of basic clause structure. As the representation of clause structure is strengthened, children are also better able to detect T/A morphemes in parent input. The use of toy talk instruction warrants further investigation to determine if these input-acquisition links can be replicated in independent samples with more diverse family demographics and if these input properties are sufficiently robust to accelerate grammatical development for children with SLI.

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